08-Jun-2006

BASIC ORDERING AGREEMENT

This is Basic Ordering Agreement (BOA) Number 272718 between BROOKHAVEN SCIENCE ASSOCIATES (hereinafter referred to as "BNL", "Brookhaven", or "Buyer") and BURLE INDUSTRIES, INC. ("BURLE" or "Seller") for the purchase and/or remanufacture (repair) of High Power RF Power Tubes. Brookhaven enters into this agreement in furtherance of its Prime Contract, No. _____ with the United States Department of Energy (DOE) for the operation of the Brookhaven National Laboratory.

The following DOE/DOD M&O contractors are authorized to use this agreement under their respective Prime Contracts:

Brookhaven National Laboratory
Argonne National Laboratory
Fermi National Accelerator Laboratory
Los Alamos National Laboratory

1. SCOPE OF THE WORK

The Seller shall provide new type 7835V2, 7835V4, 4616V4, and 4616V8 Power Tubes Product as purchased by the authorized users (Buyers). The Seller shall also remanufacture (repair) Tube Types 7835V1, 7835V2, 7835V3, 7835V4, and 4616V4 and 4616V8 as requested by the authorized uses. Each Type 7835 remanufacturing job shall be categorized as one or more of 19 separate tasks described in Attachment #1 (Work Tasks Defined). The repair of Type 4616 is categorized by two (2) tasks; One task for the Test, Cut, and Analysis (TC&A) and one task for the repair. (See Item 4.D. below.) Additionally, this Basic Ordering Agreement provides for the purchase of new Type 7651 Power Tubes and Type AJ2201 Water Separators by the authorized users.

2. PROCEDURE

Authorized users shall issue separate purchase orders referencing this Basic Ordering Agreement number when purchasing new tubes or BURLE's remanufacturing service for Types 7835 and 4616.

3. TERM

This agreement is effective as of 08-Jun-2006 and shall remain in effect through 31-Dec-2007.

4. PRICING

Pricing during the term of this agreement shall be as follows: All prices are stated in U. S. Dollars and are exclusive of freight, taxes, and other miscellaneous charges which, if applicable to the transaction, shall be added to the price to the Buyer. The applicable price shall be the one in effect on the date an individual purchase order is issued.

	01-Jul-2006 THROUGH 31-DEC-06	01-Jan-2007 THROUGH 31-Dec-2007
A. New Tube (See NOTE)		
7835V2 without Extended Warranty	$165,617.	$172,241.
7835V2 with Extended Warranty	$182,178.	$189,465.
7835V4 without Extended Warranty	$166,988.	$173,668.
7835V4 with Extended Warranty	$183,687.	$191,035.
B. Remanufactured - Type 7835V1/V2/V3/V4 (See NOTE)		
Task # (See Attachment #1 for Repair Task Descriptions)		
1A (Test, cut and analyze - Type 7835V1/V2/V3/V4)	$7,895.	$8,211.
1B (TCA including Failure Analysis)	$8,278.	$8,609.
6	$53,577.	$55,721.
11	$62,991.	$65,511.
13B	$70,404.	$73,220.

Remanufacture (continued)

Task # (See Attachment #1 for Repair Task Descriptions)

	01-JUL-2006 THROUGH 31-DEC-05	01-JAN-2007 THROUGH 31-DEC-2007
14B	$86,099.	$89,543.
14C	$116,195.	$120,843.
14D	$98,138.	$102,064.
17B	$95,315.	$99,128.
17C	$124,315.	$129,287.
17D	$107,356.	$111,651.
18A	$5,550.00	$5,720.
18B	$7,135.00	$7,420.

C. New Type 4616V4 (See NOTE)

4616V4	$38,794.	$40,346.
~~4616V8~~	~~$37,640.~~	~~$39,146.~~
AJ2201 Water Separator	$1,984.00	$2,063.

NOTE: 4616V4 - Anode with tungsten strip and ion Pump

D. Remanufactured - Type 4616RV4 (See NOTE)

Task 1 (Test, Cut, and Analyze)	$1,595.00	$1,659.
Task 1B (TCA including Failure Analysis)	$2,135.00	$2,220.
Task 2 (V4) (Remanufacture)	$24,629.00	$25,614.
Task 2 (V8) (Remanufacture)	$25,272.00	$26,283.
AJ2201 Water Separator	$1,984.00	$2,063.

E. New Type 7651 (See NOTE)

7651	$2,150.00	$2,236.

NOTES: Prices stated in this BOA for Type 7835 (both new and remanufactured) are for product purchased without RF test by BURLE.

Prices stated in this BOA for Type 4616 (both new and remanufactured) and Type 7651 (new) include RF testing.

All remanufacturing (repair) prices apply only to BURLE or RCA-manufactured tubes. Remanufacture of tubes originally manufactured by other than RCA or BURLE will be quoted on an individual basis.

Products included in this BOA are described in Attachment #7.

Several Type 7835 repair tasks and the provision to rebuild Type 7835 as Type 4617 have not shown active usage and are not priced in this BOA. Such tasks will continue to be available for the authorized users and will be priced on an "as needed" basis.

5. DELIVERY

Delivery shall be as follows unless BURLE notifies the Buyer otherwise for a specific purchase order issued under this agreement.

New Tubes - Eight (8) months maximum after receipt of order (ARO) for a quantity of one. Delivery of larger quantities ordered simultaneously will be determined at the time the order is placed.

Remanufactured Tubes

Type 7835

Tasks 1A and 1B	60 days for test and analysis after receipt of material (ARM).
Tasks 6 and 11	120 days for special remanufacturing (ARO).
Tasks 13, 14, 17and 18	160 days to 210 days (ARO).

DELIVERY (continued)

Type 4616

Task 1 and 1B	60 days for test and analysis after receipt of material (ARM).
Task 2 for Type 4616	160 days to 210 days (ARO)

6. TESTING

A. The Seller shall notify the Buyer in writing within seven workdays of final acceptance testing. The Buyer's representative must be given an opportunity to witness tests.

B. A certified copy of the factory test report (Attachment #3 , #3A, or 3B) shall be delivered with each tube. Testing procedures shall be as described in the current issue of the BURLE INDUSTRIES Acceptance Specification for Tube Type 7835 or 4616 and will not be modified without the written agreement of all parties.

7. SHIPMENT

All product hereunder shall be shipped by the Seller in accordance with the Seller's delivery commitment, FOB the Seller's plant located in Lancaster, Pennsylvania via surface motor freight at the Seller's expense. The tubes shall be packaged in an approved shipping container designated by Drawing Number CRF108D; Engineering Specification 29-36-58 FP.1, for type 7835, and 53L3 Assembly; Engineering Specification 29-53L-2P2/Mil. Spec. MIL-D-6054 for the 4616 tube types. Type 7651 product shall be shipped in containers reflective of best commercial practice.

Emergency Shipments: In the event the Buyer's requirements are such that product must be shipped via premium transportation, such costs shall be borne by the Buyer. Seller will supply full information regarding shipping weights and sizes to the Buyer's Traffic Manager. The Seller will ship the product only after authorization is given by either the Traffic Manager, or his designee, as authorized by the Buyer's Procurement Official."

8. BUYER ACCEPTANCE

Type 7835

Within sixty (60) days of receipt of a tube by the Buyer, the Buyer shall conduct such tests as it deems advisable to determine whether the tube fully complies with the drawings and/or specifications. Acceptance shall occur when the tube successfully passes inspection in accordance with BURLE Acceptance Specifications 3-1V-7835. The DOE Laboratories assume the responsibility for processing types 7835 to the level of operation desired up to rated specifications. The Seller assumes responsibility for providing quality product "ready for RF processing." The definition of "ready for RF processing" will be the successful completion of all the tests as specified in the Acceptance Specifications 3-1V-7835, Pg. 6 Series. Test data recorded by BURLE will be forwarded with the tube, i.e., Acceptance Test Data Sheet (Attachment #3, #3A, or #3B).

Product failing to RF process properly (see Warranty clauses in Attachment #5) will be accepted for return to BURLE under the standard BURLE Return Authorization (RA) System. If BURLE determines that there are no defects in materials and workmanship, then Buyer shall be liable for and reimburse Seller for returning the tube. An evaluation report or Test, Cut and Analysis (TCA) report will be furnished by Seller for each tube returned.

Type 4616

Within thirty (30) days of receipt of a tube by the Buyer, the Buyer shall conduct such tests as it deems advisable to determine whether the tube fully complies with the drawings and/or specifications. Acceptance shall occur when the tube successfully passes inspection in accordance with BURLE Acceptance Specification 3-1V-4616.

9. WARRANTY AND LIMITATION OF LIABILITY

The Warranty terms for new and remanufactured type 7835 series tubes are contained in Attachment #5. Both new and remanufactured type 4616V4 tubes and new type 7651 tubes will carry BURLE's standard "E" warranty (50 hours full adjustment; 1000 hours pro-rata for claims presented within 1-1/2 years from date of shipment). Additional Warranty and Limitation of Liability provisions as stated in Attachment #5, Section A. Paragraphs 5 through 8 of this BOA as it applies to Type 7835 apply equally to Types 4616 and 7651.

10. PAYMENT TERMS

Invoices shall be sent to the address indicated on each purchase order at the time BURLE ships a new or remanufactured tube to the Buyer. Payment terms are as follows:
Net 30 days after shipment for all new and/or remanufactured product purchased under this Basic Ordering Agreement.

11. TECHNICAL NOTES

A. Number of Rebuilds

All Type 7835 tubes returned for Rebuild #3 and higher shall have the Anode Assembly replaced. However, by mutual agreement between Buyer and Seller, and utilizing the best engineering judgment, the Anode may be left in place and be incorporated in the rebuild.

B. FAILURE DURING REPAIR / USE OF REFURBISHED ASSEMBLIES

Grid Block Assemblies, Anode Assemblies, or other assemblies refurbished by the Buyer or at the Buyer's direction will be considered for use by BURLE in the remanufacturing process. Rebuilding tasks required to affect repairs using such parts will be determined on an item-by-item basis and pricing will be quoted and agreed before such repairs are attempted. The following additional provisions apply:

(1) If, during the course of repair, a unit incorporating refurbished assemblies fails and requires additional repair effort, BURLE will immediately perform a failure analysis and provide its conclusions in the form of an evaluation report along with supporting data and information to the Buyer. This evaluation report shall be submitted within ten (10) working days of the date of the failure. A final determination as to the cause of the failure will be made jointly by the Buyer and BURLE based on the failure analysis and any further investigation deemed necessary by the Buyer in conjunction with BURLE.

(2) If it is jointly determined that the failure of the unit during repair was due solely to materials or workmanship supplied by BURLE or processes undertaken by BURLE related to the repair task in process at the time of the failure or by a preexisting condition which could have reasonably been detected by BURLE during the initial evaluation of the unit, BURLE will be solely responsible for repairing the unit at no additional cost to the Buyer. If it is jointly determined that further repair of the unit is not economically feasible, then BURLE shall have no responsibility to repair the unit and BURLE shall return the unit to the Buyer at the Buyer's expense. The Buyer shall not be liable for the costs of any materials or labor expended by BURLE in attempting to remanufacture said unit. However Test, Cut and Analysis charges for such units shall be borne by the Buyer.

(3) If it is jointly determined that the unit failed due solely to defects or degradation of refurbished materials and/or other components or materials not related to the repair task in-process at the time of failure, i.e., "Buyer-Supplied Materials", the following shall apply:

(a) If the unit failure occurred before exhaust, Buyer will be invoiced for 25% of the price for the repair task that was in process at the time of the failure.

(b) If the unit failure occurred at exhaust of later, Buyer will be invoiced for 60% of the price for the repair task that was in process at the time of the failure.

(c) In both of the cases defined in (3)(a) and (b) above, BURLE shall submit a recommendation for subsequent repairs along with the evaluation report required in paragraph (1) of this clause and shall include a cost proposal for the further-recommended repair. After review of the recommendation and any negotiation of the price for the recommended repair, Buyer shall then authorize BURLE, via written order amendment, to perform the additional recommended repairs. In the event "Buyer-Supplied Materials" caused the unit failure, BURLE's obligation for the performance of the repair task in process at the time shall cease.

(4) If a dispute arises over the cause of the unit failure or the responsibilities of the parties under the terms of this clause, the Buyer and BURLE will make a good-faith effort to reach an equitable agreement.

(5) If, in BURLE's opinion, a unit is not capable of further rebuild but the Buyer wishes to rebuild the unit, BURLE shall discuss the risk factors with the Buyer in order to reach a mutually agreed assessment of the risk prior to proceeding with the rebuild. BURLE shall assume no responsibility for further repair of the unit and the total task repair costs shall be borne by the Buyer.

12. TITLE

Title to Product shipped to BURLE for remanufacturing services is and shall remain with the Buyer and/or the Government of the United States. BURLE's risk of loss shall be in accordance with DOE Acquisition Regulations 945.3 and 945.5 (inclusive). The Buyer and/or the Government remains responsible for loss or destruction of or damage to the property except for willful misconduct or lack of good faith of contractor managerial personnel.

13. GOVERNMENT-FURNISHED PROPERTY

Attachment #6 contains a list of Government Property furnished to the Seller. The property is subject to the requirements of the General Provisions - BNL F2927 as contained in Attachment A. The Buyer and/or the U. S. Government remains responsible for loss or destruction of or damage to the property except for willful misconduct or lack of good faith of contractor managerial personnel.

14. ADDITIONAL TERMS

A. The General Provisions (Terms & Conditions) set forth in Attachment A are made a part of this agreement except where the Terms and Conditions set forth in this Basic Ordering Agreement and Attachments 1 through 7 hereto differ from or are inconsistent with the General Provisions, in which case the Terms and Conditions of this Agreement and Attachments 1 through 7 hereto shall take precedence over the General Provisions.

B. Rights to Audit are limited to authorized representatives of U. S. Government Audit Agencies such as DCAA and are not granted to representatives of Brookhaven Science Associates or the other authorized users hereof.

C. Inspection by representatives of Brookhaven Science Associates and the other authorized parties hereto is limited to non-proprietary areas of BURLE's Lancaster, PA facility.

15. ASSIGNMENT

Neither Seller nor Buyer may assign or transfer all or any part of this Agreement without the express prior written consent of the other party hereto. Provided, however, that Seller may assign or transfer this Agreement to any subsidiary or any entity acquiring or succeeding to all or substantially all of Seller's operating division performing this Agreement, and provided further that Seller may assign its claims under this Agreement to its lenders, and provided further that Buyer may assign or transfer all or any part of this Agreement to the U. S. Government or its designee.

THIS AGREEMENT DOES NOT BIND, NOR PURPORT TO BIND THE GOVERNMENT OF THE UNITED STATES.

ACCEPTED:

BURLE INDUSTRIES, INC.

BY: _____

TITLE: Vice President & General Manager

DATE: 09-Jun-06

BROOKHAVEN SCIENCE ASSOCIATES
Brookhaven National Laboratory

BY: _____

TITLE: _____

DATE: _____

ATTACHMENTS:

Attachment A - GENERAL PROVISIONS - #BNL F2927

Attachment #1 - Type 7835 Repair Tasks Definitions

Attachment #2 - Procedure for Installation and RF Processing of 7835 Series Power Tubes

Attachment #2A - Procedures for Installation and RF Processing of 7835 Series Power Tubes. (Exclusive for Brookhaven National Laboratory)

Attachment #2B - Procedures for Installation and RF Processing of 7835 Series Power Tubes. (Exclusive for Los Alamos National Laboratory)

Attachment #2C - Procedures for Installation and RF Processing of 7835 Series Power Tubes. (Exclusive for Fermi National Accelerator Laboratory)

Attachment #3 - BURLE Acceptance Test Data Sheet (BURLE Type 7835, 7835V1)

Attachment #3A - BURLE Acceptance Test Data Sheet (BURLE Type 7835V2, 7835V3, 7835V4)

Attachment #3B - BURLE Acceptance Test Data Sheet (BURLE Type 4616)

Attachment #4 - BURLE Return Authorization Service Report

Attachment #5 - 7835/V1/V2/V3/V4/ Warranty

Attachment #6 - Manifest of Government-Furnished Property

Attachment #7 - Product Descriptions

ATTACHMENT #1

Type 7835 Repair Tasks Descriptions

Task 1A - Visual Inspection, Test and Analysis

- Examine each tube for external damage. If the tube appearance is satisfactory, perform basic electrical tests. Tubes failing this test, and all other tubes, shall be cut open and the sub-assemblies analyzed for potential remanufacturing. Tubes not repairable shall be scrapped. All other candidates for remanufacturing shall be assigned the appropriate Remanufacturing Task.

Task 1B

- Examine each tube for external damage. If the tube appearance is satisfactory, perform basic electrical tests. Tubes failing this test, and all other tubes, shall be cut open and the sub-assemblies analyzed for potential remanufacturing. Tubes not repairable shall be scrapped. All other candidates for remanufacturing shall be assigned the appropriate Remanufacturing Task.
- Perform a complete Failure Analysis and prepare and submit a Failure Analysis Report to the owning agency (User).
  NOTE: This Task is identical to Task 1, but includes the Failure Analysis and Report.

Task 2A*

- Replace the Input Seal Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 2B*

- Replace the Grid Block Center Conductor.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 3A*

- Replace the Input Seal Assembly and the Grid Block Center Conductor.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 3B*

- Rebuild the Anode Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 4A*

- Replace the Grid Block.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 4B*.

- Replace the Anode Envelope Assembly.
- ~~Replace or reprocess all minor parts and assemblies.~~
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

**RF test options associated with Tasks 2A, 2B, 3A, 3B, 4A, 4B, 5, 5A, 8A, 8B, 9A, 9B, 10A, 10B, 10C,10D, and 19 are listed for reference only and are not priced in this BOA.*

Task 5

- Remove and replace up to five (5) Cathodes determined to be stretched beyond acceptable limits or otherwise requiring replacement. The work of this task is limited to a best effort, one attempt only basis (no recycling through major process steps if the first attempt fails). The work may be terminated at any stage if the scope of the work required to complete the task increases.

Task 5A*

- High Power Process and RF Pulse Test tubes remanufactured under Task 5 or Task 6. Efforts will be made to run these products through normal acceptance specifications. However, performance against these specifications is not a criteria for acceptance. These tests are performed on a best effort basis and may be terminated at any time if the scope of work required to complete the task increases.

Task 6

- Reassemble the Grid Block after cleaning and install all new Cathodes. Re-use all major sub-assemblies. The work is limited to a best effort, one attempt basis (no recycling through major process steps if the first attempt fails). The work may be terminated at any stage if the scope of work required to complete the task increases.

Task 7*

- Add new weld rings to Sealing Sleeves, Mount Assembly and Input Assembly, as required.

Task 8A*

- Replace the Input Seal Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 8B*

- Replace the Grid Block Center Conductor.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 9A*

- Replace the Input Seal Assembly and Grid Block Center Conductor.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 9B*

- Rebuild the Anode Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 10A*

- Rebuild the Anode Assembly and replace the Grid Block Center Conductor.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 10B

- Rebuild the Anode Assembly and replace the Input Seal Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 10C*

- Replace the Grid Block.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 10D*

- Replace the Anode Envelope Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- RF High Power Process the tube.
- Test to the 7835V1 standard acceptance criteria.

Task 11

- Reassemble the Grid Block after cleaning and install all new Cathodes. Re-use all major sub-assemblies. The work is limited to a best effort, one attempt basis (no recycling through major process steps if the first attempt fails). The work may be terminated at any stage if the scope of work required to complete the task increases.
- Install new Weld Rings as required.

Task 12A*

- Replace the Input Seal Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 12B

- Replace the Grid Block Center Conductor.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 13A

- Replace the Input Seal Assembly and the Grid Block Center Conductor.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 13B

- Rebuild the Anode Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 14A

- Rebuild the Anode Assembly and replace the Grid Block Center Conductor.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 14B

- Rebuild the Anode Assembly and replace the Input Seal Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 14C

- Replace the Grid Block.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 14D

- Replace the Anode Envelope Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 15A

- Replace the Input Seal Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 15B

- Replace the Grid Block Center Conductor.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 16A

- Replace the Input Seal Assembly and Grid Block Center Conductor.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 16B

- Rebuild the Anode Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 17A

- Rebuild the Anode Assembly and replace the Grid Block Center Conductor.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 17B

- Rebuild the Anode Assembly and replace the Input Seal Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 17C

- Replace the Grid Block.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 17D

- Replace the Anode Envelope Assembly.
- Replace or reprocess all minor parts and assemblies.
- Replace or reprocess Grids and install new Cathodes.
- Replace or reprocess Cathode Springs, Spring Retainer and Cathode Pantograph, as required.
- Install new Getters and Exhaust Tubulation.
- Install new Weld Rings as required.
- Test to the 7835V1 standard acceptance criteria.
- **DO NOT** High Power Process the tube.

Task 18A

- Rebuild the Input Seal Assembly to accommodate the addition of Ion Pump(s).
- Replace or Add one (1) Physical Electronics Item #648263 (2 Liter per Second) Ion Pump to a repaired tube.

Task 18B

- Rebuild the Input Seal Assembly to accommodate the addition of Ion Pump(s).
- Replace or Add two (2) Physical Electronics Item #648263 (2 Liter per Second) Ion Pumps to a repaired tube.

Task 19

- Convert an existing 7835 tube into a Type 4617 tube. This rebuild will require, at a minimum, a new Grid Block Assembly. Additional tasks may be necessary, as required. These additional repair tasks will be quoted on an individual basis as part of the TC&A.

**RF test options associated with Tasks 2A, 2B, 3A, 3B, 4A, 4B, 5, 5A, 8A, 8B, 9A, 9B, 10A, 10B, 10C, 10D, and 19 are listed for reference only and are not priced in this BOA.*

ATTACHMENT #2

Procedure For Installation, RF Processing and Operation of the BURLE 7835/V1/V2/V3 High Power Triode

GENERAL

This Application Guide includes general information useful in the care and maintenance, installation and operation of BURLE Tube Type 7835/V1.

A. UNPACKING THE TUBE:

Upon receipt of the 7835/V1 tube, the recipient should visually inspect the shipping crate for damage or other indications of mishandling during shipment. If visual damage is evident, contact BURLE Application Engineering immediately.

After inspecting the crate and contents, cut and remove the metal seals that secure the hasps for the top of the crate. Open the top. Open the drop flaps on the sides of the crate, cut and remove the wire threaded through the four wing nuts. Remove the wing nuts.

Connect the lifting hook through the eyebolt provided with the tube. Carefully lift the tube from the crate. Never lift the tube by any other means than by the lifting device provided. Storage for the tube when not in use should be in the shipping crate only. Use a crane or hoist having at least a 1,000 lb. rating. Store crate for future use.

B. TUBE VACUUM TEST:

A vacuum test should be performed on the tube within thirty (30) days after receipt at customer's location or 60 days after shipment, whichever is sooner. To perform the Vacuum Test, put a spot knocking supply between grid and cathode and raise the voltage to 2kV. A leakage current of less than 10μA is acceptable. If the tube is supplied with an ion pump, the Purchaser must operate the ion pump at sixty (60) day intervals for as long as necessary to maintain optimum vacuum conditions of less than 20 microamperes of ion current.

C. TUBE INSTALLATION:

Make sure all circuit contact areas and ceramics insulators on the tube are clean. All areas of the cavity that make electrical contact to the tube should be checked. If spring finger contact surfaces are dirty or arced, they should be cleaned or replaced before a new tube is installed.

During the assembly of the tube and cavity, extreme care should be taken to avoid damage to the tube and cavity. The tube ceramic insulators are particularly vulnerable at this time. Never let the cavity finger contacts rub across the ceramic. This incidental contact will deposit metal on the ceramics and may cause voltage breakdown problems. Tube ceramics should be kept free also of dust, moisture and other foreign matter. Never force the fit between cavity mating connectors and the tube terminals when installing the tube. Avoid excessive mechanical stress, particularly on the plate ceramics and filament connectors. If it does not fit properly, stop and determine why.

D. PRELIMINARY OPERATING PROCEDURES:

In accordance with the Tube Bulletin, make sure that the coolant system is supplying the proper flow of high purity water to all areas and that no leaks exist. The cavity must be pressurized to the recommended pressure and all protection devices must be checked to insure that they are functioning properly.

E. TUBE OPERATION - BREAK-IN AND SEASONING PROCEDURE:

CAUTION: If installed, the ion pump must be turned off only during Step 1 of this procedure and should be operated at all times thereafter. If at anytime the ion pump current exceeds 100μA, stop the procedure and allow the pump to operate until the current is reduced to 20μA.

1. Filament Break-In:

   Apply filament voltage in the following manner:

   a. Raise the filament current to 2000 amps in increments of 400 amps over 5 minutes.

   b. Increase filament current in steps of 1000 amps. Typically increases should be made every two or three minutes until the 6800 amp operating level is obtained.

   c. Typical time = 0.5 hours.

2. Filament Aging:

   a. If an ion pump is available, it should be turned on at this point. Let the tube operate at the typical filament current for 15 to 30 minutes without plate voltage. This will give the tube's internal getter and ion pump (if available) an opportunity to pump any gas released during activation of the filaments.

   b. Typical time = 0.5 hours.

3. Precautions To Be Observed During The Entire Break-In Procedure:

   a. During the application of RF drive and plate voltage, observations of the cathode and plate current pulses, the missing pulse indicator (if available) and the ion pump current (if available) are used to judge the progress of tube vacuum clean-up.

      The cathode and plate current pulses and/or the missing pulse indicator can be used to judge the frequency of internal tube arcs. Internal tube arcs may increase as the power or voltage applied to the tube is increased. If the tube is operated for a period of time at a constant level of power, the frequency of internal arcs will decrease, indicating that the normal clean-up is taking place and the power input can be increased to a higher level. An increasing frequency of internal arcs or a burst of internal arcs should be countered by decreasing the power and running at a lower level before again increasing the power.

      If an ion pump is available, it also should be used as an indicator of vacuum clean-up. Internal tube arcs usually show up as a short burst or increase in ion pump current. Absence of internal arcs will be accompanied by a decrease in ion pump current.

      Normal outgassing of tube elements after an increase in power will be indicated by a gradual increase in ion pump current. The current will then go through a peak and begin to decrease if normal clean-up is taking place.

      If the ion pump current increases rapidly or continues to increase without peaking out, the power should be decreased and break-in continued at a lower level before again increasing the power.

4. RF Drive Aging:

   a. No plate voltage should be applied to the tube during this portion of the break-in procedure.

   b. Reduce the RF drive to 20% of maximum pulse width*. Apply RF drive at 20% of the peak power*. Increase the drive amplitude in 10% steps while observing the precautions outlined in Step 3. If tube arcs or missing pulses do not appear to be stabilizing as discussed in Step 3, reduce the drive amplitude until the tube will operate trip/arc free at the previous level. If an ion pump is available, control the increases in RF drive power to maintain the ion pump current to below 100μA.

c. Continue to increase the drive amplitude until full power is obtained. Increase the duty cycle in steps of 10% until full drive* is applied while observing the precautions in Step. 3.

d. Typical time = 8 hours.

5. Reduced Average Power RF Operation:

CAUTION: Never apply plate voltage without RF drive.

a. Reduce the plate modulator and RF drive pulse widths to approximately 20% of typical full power value*. Apply minimum plate voltage while observing the pulse waveforms for plate and/or grid breakdown or arcing activity. Plate voltage and plate current should be observed at all times on an oscilloscope while processing the tube. Raise the plate voltage in steps of 5% as the reduction in plate/grid arcing activity allows governed by the precaution in Step 3. If slumping should occur, as observed on the plate current or power output level, the plate voltage should be reduced to the minimum level. Allow the tube to operate at this level until the plate current has recovered to the level previously recorded for minimum plate voltage. The tube should be operated at this level for 4 hours or more before proceeding to a higher level.

b. Typical time = 16 hours.

6. Full Power RF Operation:

a. Operate the tube to full peak power* at reduced duty cycle. As the tube ages and the arcing subsides, increase the duty cycle in 10% steps until full power is achieved. If slumping or arcing is observed, repeat the procedure outlined in Step 5, above.

b. Typical time = 24 hours.

7. Full Power Seasoning:

a. When the procedures listed above have been completed and all precautions observed to minimize arcing and cathode slumping during break-in, the tube should be operated at full power* for approximately 48 hours. During this break-in seasoning, all protection circuits must be operating and the ion pump, if available, must be capable of shutting the system down if the ion current exceeds 100μA. Resume operation only when the ion pump current is reduced to 20μA or less; if no ion pump is available, resume full power operation only after repeating Step 6 and observing the precautions outlined in Item 3.

b. Typical time = 48 hours.

* See Attachment #5, Section 2.b. for operating parameters.

8. Recorded Readings:

a. During the break-in procedure and after the tube is operating satisfactorily at the desired power output, complete operating parameters as well as control settings must be recorded for future reference. Maintain a record of filament operating hours for the life of the tube.

9.

Step	Operation	Typical Time
1	Filament Break-In	0.5 hours
2	Filament Age	0.5 hours
4	RF Drive Aging	8.0 hours
5	Reduced Average Power RF Operation	16.0 hours
6	Full Power RF Operation	24.0 hours
7	Full Power Seasoning	48.0 hours

10. Storage Precaution:

a. Remove all water from the coolant courses before storage or shipment.

F. POWER OPERATION:

1. During the first few hours of full power operation, the tube operating parameters must be monitored closely and recorded. It may be necessary to make minor adjustments in loading, tuning, VSWR, etc., during this time. If excessive over-loading should occur, the power level should again be reduced for a short period of time and then slowly increased at a rate determined by the tube behavior.

2. Gas Test:

When the tube is installed in the cavity for initial tests and any other time the tube's condition is in question, a gas check should be made. This test is made as follows:

a. Turn on the filaments and increase the filament current to the normal operating level.

b. Apply plate voltage, Eb = -45 volts dc.

c. Vary the grid voltage, Ec, from zero to a low positive value, for a grid current, Ic = 50 amps dc.

3. Read the gas current on a microampere meter connected in series with the -45 volt Eb supply.

4. Read initial gas current and the gas current again after 5 minutes.

5. Record gas test data (Ec, Ic, Igas) in Tube Log for comparison with later gas tests.

G. TUBE FAILURE MODES:

The potential failure modes of the 7835/V1 are:

1. Low emission.
2. Loss of vacuum.
3. Shorted elements.

Low emission is the most prevalent and normal cause of ultimate tube failure. This failure mechanism will eventually prevail if none of the other failure mechanisms occur. Emission wear-out of the filaments can be delayed by operating the filament current just above the level required to give the desired plate current. On a new tube, adequate emission current for most applications can be obtained by operating the filament at 90% to 95% of the recommended value. As operating time is accumulated, the filament current can be increased as required to compensate for filament aging. Eventually, after extended service, a point will be reached where even with the filament current set at the rated maximum value, the plate current will be too low for the intended service.

Low emission can also be the result of operating the tube with poor vacuum pressure. This condition is generally referred to as poisoned emission or poisoned filaments. In this case, the emission can sometimes be recovered by first restoring the vacuum pressure to a low level by allowing the internal getter to pump the gas with filament voltage only applied for several hours, followed by returning the tube to operation as described in the break-in procedure. (Refer to Item E, above).

Loss of vacuum is due to a leak in the tube's vacuum envelope. The leak can be caused by inadvertent stress applied to the tube terminals, impact of a tool or connector against the ceramic, loss of coolant, or localized over-heating. A total loss of vacuum can be detected by one of the following indications:

a. Filament current is much higher than normal.

b. Voltage hold-off between elements is greatly reduced.

Shorted elements can be detected with either an ohmmeter or a megger connected between the tube terminals. However, if the filaments of the tube are on, the measuring device can draw emission current from the tube resulting in an incorrect reading. NOTE: Continuity should normally appear between the two coaxial filament terminals. Some elements are shorted only when the filaments are heated. Reduced voltage hold-off, not truly short circuits, may be evidenced by lower-than-normal breakdown voltage between the suspect elements. Arc tracks or conductive deposits on the ceramics can produce the latter symptoms.

In some cases, tubes can be recovered from a shorted failure by spot knocking, passing AC or DC current through the short circuit. In this latter case, it is recommended that the user consult BURLE Applications Engineering before attempting to correct the problem.

5. For warranty consideration or analysis preparatory to rebuilding, adjustment under warranty, if applicable, will be made only when:

a. Tube is returned in accordance with instructions issued by BURLE. Return is not to be made until a Return Authorization (RA) is issued by BURLE. Charges for return transportation costs prepaid by the customer will be accepted by BURLE if adjustment is subsequently allowed.

b. Tube has not been subjected to abuse; improper installation or application; alteration; accident; or negligent use.

c. Original tube identification markings have not been removed, defaced, or altered.

d. BURLE inspection and test reveals that tube meets warranty terms.

e. All claims must include the following information:

1. Tube type
2. Quantity and billing price of type claimed defective
3. Serial number/Date code
4. Ship date
5. Customer order number
6. Specific reason for return request.
7. Break-In and service data

6. Product returned must reference RA number on cartons/packages. Request Return Authorization from:

BURLE INDUSTRIES, INC.
Customer Service
1000 New Holland Avenue
Lancaster, PA 17601-5688
1-800-366-2875
FAX: 717-295-6096

7. Authorized Returns - Return to:

BURLE INDUSTRIES, INC.
Tube Products Division
1000 New Holland Avenue
Building No. 7A
Lancaster, PA 17601-5688
RA Number _____

OPERATING PARAMETERS THAT MUST BE RECORDED DAILY:

Date: _____

Plate Voltage (kV)	_____
Plate Current (amps)	_____
Cathode Current (amps)	_____
Cathode Voltage (volts)	_____
Drive Power (kW)	_____
Output Power (MW)	_____
Filament Voltage (volts)	_____
Filament Current (amps)	_____
Pulse Length (μsec)	_____
Pulse Repetition Rate (Hz)	_____
Operating Hours (filament) (hours)	_____
Ion Pump Gas Pressure (μ amps) (if available)	_____
Missing Pulses	_____
Trip-Outs	_____

At least once every six months, or more often if conditions warrant, a gas check should be made as outlined with these instructions.

ATTACHMENT #2A

Procedure For Installation, RF Processing and Operation of the BURLE 7835 High Power Triode

EXCLUSIVE FOR BROOKHAVEN NATIONAL LABORATORY

This Application Guide includes general information useful in the care and maintenance, installation and operation of BURLE Tube Type 7835/V1.

A. UNPACKING THE TUBE:

Upon receipt of the 7835/V1 tube, the recipient should visually inspect the shipping crate for damage or other indications of mishandling during shipment. If visual damage is evident, contact BURLE Application Engineering immediately.

After inspecting the crate and contents, cut and remove the metal seals that secure the hasps for the top of the crate. Open the top. Open the drop flaps on the sides of the crate, cut and remove the wire threaded through the four wing nuts. Remove the wing nuts.

Connect the lifting hook through the eyebolt provided with the tube. Carefully lift the tube from the crate. Never lift the tube by any other means than by the lifting device provided. Storage for the tube when not in use should be in the shipping crate only. Use a crane or hoist having at least a 1,000 lb. rating. Store crate for future use.

B. TUBE VACUUM TEST:

1. Place a spot knocking supply between grid and cathode; apply 2kV. (Reverse polarity repeat test).

2. Move the supply between grid and anode; apply 2kV.

Measured currents may be the result of field emission. If leakage currents are > 10μ amps, increase the Power Supply voltage until a spark-down occurs. Continue this procedure until low currents are measured, < 10μ amps.

3. If tube is equipped with a mini-appendage ion pump, apply 3 to 3.5 kV to the pump without the magnet attached. The leakage current should be < 1μ amp. If leakage currents are observed, increase the pump voltage until a spark-over occurs within the pump. This procedure should reduce the current to < 1μ amp. Install the magnet and apply pump voltage. A short burst of ion current may appear. If no ion current is evident, you may gently heat the pump and tubulation to release some ions. This procedure should start the pump.

C. TUBE INSTALLATION:

Make sure all circuit contact areas and ceramics insulators on the tube are clean. All areas of the cavity that make electrical contact to the tube should be checked. If spring finger contact surfaces are dirty or arced, they should be cleaned or replaced before a new tube is installed.

During the assembly of the tube and cavity, extreme care should be taken to avoid damage to the tube and cavity. The tube ceramic insulators are particularly vulnerable at this time. Never let the cavity finger contacts rub across the ceramic. This incidental contact will deposit metal on the ceramics and may cause voltage breakdown problems. Tube ceramics should be kept free also of dust, moisture and other foreign matter. Never force the fit between cavity mating connectors and the tube terminals when installing the tube. Avoid excessive mechanical stress, particularly on the plate ceramics and filament connectors. If it does not fit properly, stop and determine why.

D. PRELIMINARY OPERATING PROCEDURES:

Make sure that the coolant system is supplying the proper flow of high purity water, in accordance with the Tube Bulletin, to all areas and that no leaks exist. The cavity must be pressurized to the recommended pressure and all protection devices must be checked to insure that they are functioning properly.

E. TUBE OPERATION - BREAK-IN AND SEASONING PROCEDURE:

<u>CAUTION</u>: If tube is equipped with an ion pump, the pump must be turned off only during Step 1 of this procedure and should be operated at all times thereafter.

1. Filament Break-In:

a. Bring the filament power supply on. Increase the current to the operating level at a speed set by the Variac or power supply controller.

b. After five minutes, measure the gas pressure using the conventional 50 amp Ig method.

2. Filament Aging:

a. If an ion pump is available, it should be turned on at this time. Let the tube operate at the typical filament current for 30 minutes without applying RF drive. This will give the tube's internal getter and ion pump (if available) an opportunity to pump any gas released during activation of the filaments.

However, do not proceed to RF drive aging until the ion pump current is <10μA.

3. Precaution To Be Observed During The Entire Break-In Procedure:

a. During the application of RF drive and plate voltage, observations of the cathode and plate current pulses, the missing pulse indicator (if available) and the ion pump current (if available) are used to judge the progress of tube vacuum clean-up.

The cathode and plate current pulses and/or the missing pulse indicator can be used to judge the frequency of internal tube arcs. Internal tube arcs may increase as the power or voltage applied to the tube is increased. If the tube is operated for a period of time at a constant level of power, the frequency of internal arcs will decrease, indicating that the normal clean-up is taking place and the power input can be increased to a higher level. An increasing frequency of internal arcs or a burst of internal arcs should be countered by decreasing the power and running at a lower level before again increasing the power.

If an ion pump is available, it also should be used as an indicator of vacuum clean-up. Internal tube arcs usually show up as a short burst or increase in ion pump current. Absence of internal arcs will be accompanied by a decrease in ion pump current.

Normal outgassing of tube elements after an increase in power will be indicated by a gradual increase in ion pump current. The current will then go through a peak and begin to decrease if normal clean-up is taking place.

If the ion pump current increases rapidly or continues to increase without peaking out, the power should be decreased and break-in completed at a lower level before again increasing the power.

4. RF Drive Aging:

a. No plate voltage should be applied to the tube during this portion of the break-in procedure.

b. Reduce the RF drive to 20% of maximum pulse width. Apply RF drive at 20% of the peak power. Increase the drive amplitude in 10% steps while observing the precautions outlined in Step 3. If tube arcs or missing pulses do not appear to be stabilizing as discussed in Step 3, reduce the drive amplitude until the tube will operate trip/arc free at the previous level. If an ion pump is available, control the increases in RF drive power to maintain the ion pump current to below 100μA.

c. Continue to increase the drive amplitude until full power is obtained. Increase the duty cycle in steps of 10% until full drive is applied while observing the cautions in Step. 3.

d. Typical time = 8 hours.

. **Reduced Average Power RF Operation: (Plate circuit detuned method)**

CAUTION: **1. Never apply plate voltage without RF drive.**
2. Check for proper operation of all protection circuits.

a. Detune the cavity output circuit.

b. Reduce pulse length to 200 μsec and apply drive power to approximately the 50 kW level.

c. Raise the anode pulse voltage to 10 kV.

d. Increase the drive power to the 200 kW level, recording plate current, ion pump current and tripouts. Use the ion pump pressure, if available, as a guide to further conditioning as follows:

1. <10μ amps - proceed with conditioning.
2. 10 to 100μ amps - reduce power and proceed with caution.
3. >100μ amps - cease operation and allow tube to recover.

e. At 200 kW of drive, the anode current should be at a level which would produce 5 Megawatts if the system were on tune, approximately 300 amps. Operate the tube at this level until an acceptable pressure is observed and the tube will operate continuously without a trip for a minimum of one hour. If the tube is not equipped with an ion pump and a slump in plate current or output power should occur, the plate voltage should be further reduced. Allow the tube to operate at this level until the tube has recovered to the previous level of operation. Increase the pulse length in 100 or 200 μsec increments until the full RF pulse width is attained. The tube should now be operating at full anode dissipation with a minimum RF voltage swing in the output circuit.

NOTE: Not all cavities will detune to this extent. Operate at the maximum plate current attainable.

6. **Full Power RF Operation:**

At a plate voltage of 10 kV and full RF pulse width, bring the plate circuit to resonance. Increase the plate voltage in 3 kV steps, as dictated by the number of plate tripouts and the ion pump pressure, until full output power has been reached. The tube should now be operating at a minimum of 5 Mw peak output power at full duty cycle. (Refer to E.5.d, Conditioning Guide).

7. **Full Power Seasoning:**

When the procedures listed above have been fully complied with, tube seasoning is completed when operation for one full hour, trip free, can be achieved. Final acceptance data may now be taken.

8. **Recorded Readings:**

a. During the break-in procedure, and after the tube is operating satisfactorily at the desired power output, complete operating parameters as well as control settings must be recorded for future reference. Maintain a record of filament operating hours for the life of the tube.

9.

Step	Operation	Typical Time
1	Filament Break-In	0.5 hours
2	Filament Age	0.5 hours
4	RF Drive Aging	8.0 hours
5	Reduced Average Power RF Operation	16.0 hours
6	Full Power RF Operation	24.0 hours
7	Full Power Seasoning	48.0 hours

10. **Storage Precaution:**

a. Remove all water from the coolant courses before placing the tube in storage or shipment off site.

b. If tube is equipped with an ion pump, it is recommended that the pump be operating at all times. If this is not possible, the pump should be operated every 3 months for a period of 24 hours.

F. POWER OPERATION:

1. During the first few hours of full power operation, the tube operating parameters must be monitored closely and recorded. It may be necessary to make minor adjustments in loading, tuning, VSWR, etc., during this time. If excessive over-loading should occur, the power level should again be reduced for a short period of time and then slowly increased at a rate determined by the tube behavior.

2. Gas Test:

When the tube is installed in the cavity for initial tests and any other time the tube's condition is in question, a gas check should be made. This test is made as follows:

a. Turn on the filaments and increase the filament current to the normal operating level.

b. Apply plate voltage, Eb = -45 volts dc.

c. Vary the grid voltage, Ec, from zero to a low positive value, for a grid current, Ic = 50 amps dc.

3. Read the gas current on a microampere meter connected in series with the -45 volt Eb supply.

4. Read initial gas current and the gas current again after 5 minutes.

5. Record gas test data (Ec, Ic, Igas) in Tube Log for comparison with later gas tests.

G. TUBE FAILURE MODES:

The potential failure modes of the 7835/V1 are:

1. Low emission.

2. Loss of vacuum.

3. Shorted elements.

Low emission is the most prevalent and normal cause of ultimate tube failure. This failure mechanism will eventually prevail if none of the other failure mechanisms occur. Emission wear-out of the filaments can be delayed by operating the filament current just above the level required to give the desired plate current. On a new tube, adequate emission current for most applications can be obtained by operating the filament at 90% to 95% of the recommended value. As operating time is accumulated, the filament current can be increased as required to compensate for filament aging. Eventually, after extended service, a point will be reached where even with the filament current set at the rated maximum value, the plate current will be too low for the intended service.

Low emission can also be the result of operating the tube with poor vacuum pressure. This condition is generally referred to as poisoned emission or poisoned filaments. In this case, the emission can sometimes be recovered by first restoring the vacuum pressure to a low level by allowing the internal getter to pump the gas with filament voltage only applied for several hours, followed by returning the tube to operation as described in the break-in procedure. (Refer to Item E, above).

Loss of vacuum is due to a leak in the tube's vacuum envelope. The leak can be caused by inadvertent stress applied to the tube terminals, impact of a tool or connector against the ceramic, loss of coolant, or localized over-heating. A total loss of vacuum can be detected by one of the following indications:

a. Filament current is much higher than normal.

b. Voltage hold-off between elements is greatly reduced.

Shorted elements can be detected with either an ohmmeter or a megger connected between the tube terminals. However, if the filaments of the tube are on, the measuring device can draw emission current from the tube resulting in an incorrect reading. NOTE: Continuity should normally appear between the two coaxial filament terminals. Some elements are shorted only when the filaments are heated. Reduced voltage hold-off, not truly short circuits, may be evidenced by lower-than-normal breakdown voltage between the suspect elements. Arc tracks or conductive deposits on the ceramics can produce the latter symptoms.

In some cases, tubes can be recovered from a shorted failure by spot knocking, passing AC or DC current through the short circuit. In this latter case, it is recommended that the user consult BURLE Applications Engineering before attempting to correct the problem.

4. For warranty consideration or analysis preparatory to rebuilding, adjustment under warranty, if applicable, will be made only when:

a. Tube is returned in accordance with instructions issued by BURLE. Return is not to be made until a Return Authorization (RA) is issued by BURLE. Charges for return transportation costs prepaid by the customer will be accepted by BURLE if adjustment is subsequently allowed.

b. Tube has not been subjected to abuse; improper installation or application; alteration; accident; or negligent use.

c. Original tube identification markings have not been removed, defaced, or altered.

d. BURLE inspection and test reveals that tube meets warranty terms.

e. All claims must include the following information:

1. Tube type
2. Quantity and billing price of type claimed defective
3. Serial number/Date code
4. Ship date
5. Customer order number
6. Specific reason for return request.
7. Break-In and service data

5. Product returned must reference RA number on cartons/packages. Request Return Authorization from:

BURLE INDUSTRIES, INC.
Customer Service
1000 New Holland Avenue
Lancaster, PA 17601-5688
1-800-366-2875
FAX: 717-295-6096

6. Authorized Returns - Return to:

BURLE INDUSTRIES, INC.
Tube Products Division
1000 New Holland Avenue
Building No. 7A
Lancaster, PA 17601-5688
RA Number _____

7. Recommended Operating Parameters to be recorded During the Conditioning Process and at Acceptance:

a. Plate Voltage (kV)
b. Plate Current (amps)
c. Drive Power (kW)
d. Output Power (Mw)
e. Filament Voltage (volts)
f. Filament Current (amps)
g. Pulse Length (μsec)
h. Pulse repetition Rate (Hz)
i. Operating Hours (filament hours)
j. Operating Hours (plate voltage on)
k. Ion Pump Gas Current (μ amps)
l. Internal Gas Current (μ amps) (at 5 min. point 50 amp Ig method)
m. Tripouts

OPERATING PARAMETERS THAT MUST BE RECORDED DAILY:

Date: _____

Plate Voltage (kV) _____

Plate Current (amps) _____

Cathode Current (amps) _____

Cathode Voltage (volts) _____

Drive Power (kW) _____

Output Power (MW) _____

Filament Voltage (volts) _____

Filament Current (amps) _____

Pulse Length (μsec) _____

Pulse Repetition Rate (Hz) _____

Operating Hours (filament) (hours) _____

Ion Pump Gas Pressure (μ amps) (if available) _____

Missing Pulses _____

Trip-Outs _____

At least once every six months, or more often if conditions warrant, a gas check should be made as outlined with these instructions.

ATTACHMENT #2B

Procedure for Installation, RF Processing and Operation of BURLE 7835 High Power Triode

EXCLUSIVE FOR LOS ALAMOS NATIONAL LABORATORY

NOTE

If the tube to be conditioned is not equipped with an ion pump, disregard the instructions in this Procedure which refer to the ion pump current or to the ion pump power supply.

1. After installation of the tube in the power amplifier (PA) is complete, prepare the amplifier for a tube gas check.

NOTE

While the tube filament current is being increased per paragraph 2, leave the tube ion pump power supply turned off except as follows: Turn the ion pump power supply on momentarily during each of the pauses between filament current increases. Note and record the ion pump current reading in the logbook at each current increase step. When the ion current goes below 1 milliamp (mA), the power supply may be left on. Also take an ion pump supply current reading each time a gas check current reading is taken.

2. When preparation for the gas check is complete, apply voltage to the tube filaments as follows: Increase the filament voltage from zero until the filament current is at 2000 amps. Pause for three minutes. Then increase the filament current in 1000 amp steps, followed by a three-minute pause each time until reaching 6800 amps. After reaching 6800 amps, begin the gas check.

CAUTION

If the filament supply voltage is not between 4.2 and 5.2 volts (v) at 6800 amps, discontinue this Procedure.

NOTE

The filament supply voltage will ordinarily be 4.9 +/- 0.2 volts at 6800 amps.

3. After the gas check has been completed, reduce the filament current to zero in steps of about 1000 amps per minute until reaching 3000 amps. Then reduce the filament power supply voltage to zero. Prepare the amplifier for normal operation of the tube.

4. After the amplifier is prepared for normal operation, apply voltage to the 7835 tube filaments in the same step as in paragraph 2. Leave the ion pump power supply turned off as in paragraph 2. Take momentary ion pump supply current readings as in paragraph 2. As in paragraph 2, the ion pump power supply may be turned on when the supply current goes below 1 mA. Continue to record the ion pump supply current every few minutes. Proceed to the next step when the ion pump current goes below 100 microamps (μA). If the tube is not equipped with an ion pump, wait one hour before proceeding.

CAUTION

Before accumulating 50 hours of filament running time, if it is necessary to operate the 7835 tube for more than 15 minutes without RF power applied to its input, reduce the filament current to 5400 amps (about 80% of normal). When ready to apply RF to the tube input, increase the filament current back to 6800 amps. After 50 hours of filament operation, do not change the filament current from 6800 amps unless absolutely necessary, even if not applying RF to the tube input.

CAUTION

Never operate the 7835 under high voltage (HV) without full RF power applied to its input. Full input power is approximately 225 kilowatts (kW) from the intermediate power amplifier (IPA), equivalent to a 7835 cathode current (Ik) of 300 amps peak, measured at the center of the pulse.

CAUTION

During conditioning, if it is necessary to turn the filaments off or if they are found off, resume conditioning at the same place in the Procedure at which it was discontinued. Do not proceed, however, until the ion pump current limit in the previous step is satisfied. Reapply power to the tube filaments as described in paragraph 1.

CAUTION

If the tube is not equipped with an ion pump, the following applies: After the filaments are at 6800 amps, do not apply RF to the input of the tube for at least one and one-half hours. If the tube is not equipped with an ion pump and if high voltage is to be applied to it, wait at least one more hour before doing so.

5. Check that the power amplifier gate "OUT" cable from unit 1181 in rack R03 is disconnected. This will keep plate voltage from being applied to the 7835 tube. Set the pulse repetition frequency (PRF) at 30 hertz (Hz) and the pulse width (PW) at 100 microseconds (μs). Turn on the high voltage. This will apply plate voltage to the intermediate power amplifier (IPA).

6. Adjust the IPA "de-Q-ing" resistance coupling capacitor ("swamping") for a 7835 tube Ik of 300 +/- 5 amps at the center of the pulse. Wait for 10 minutes, then adjust the PA input tuner for maximum forward power from the IPA and minimum power reflected back to the IPA. Observe and record the ion pump supply current every few minutes. Do not leave the ion pump supply turned on continuously if the current is over 1 mA.

7. Wait for at least 10 minutes and until the ion pump supply current goes below 100μA. If the tube is not ion pump equipped, wait one hour. Then change the PRF to 60 Hz. Continue to record the ion pump current. Continue to leave the ion pump supply turned off if the current is above 1 mA.

8. Wait for at least 10 minutes and until the ion pump supply current goes below 100μA. If the tube is not ion pump equipped, wait one hour. Then change the PRF to 120 Hz. Continue to record the ion pump current and keep the pump turned off if the current is above 1 mA.

9. Wait for at least 10 minutes and until the ion pump supply current goes below 100μA. If the tube is not ion pump equipped, wait one hour. Then change the PW to 200μs. Continue to record the ion pump current and keep the pump turned off if the current is above 1 mA.

10. Wait for at least 10 minutes and until the ion pump supply current goes below 100μA. If the tube is not ion pump equipped, wait one hour. Then change the PW to 400μs. Continue to record the ion pump current and keep the pump turned off if the current is above 1 mA.

11. Wait for at least 10 minutes and until the ion pump supply current goes below 100μA. If the tube is not ion pump equipped, wait one hour. Then change the PW to 600μs. Continue to record the ion pump current and keep the pump turned off if the current is above 1 mA.

12. Wait for at least 10 minutes and until the ion pump supply current goes below 100μA. If the tube is not ion pump equipped, wait one hour. Then change the PW to 800μs. Continue to record the ion pump current and keep the pump turned off if the current is above 1 mA.

13. Wait for at least 10 minutes and until the ion pump supply current goes below 100μA. If the tube is not ion pump equipped, wait one hour. Then change the PW to 900μs. Continue to record the ion pump current and keep the pump turned off if the current is above 1 mA.

14. Wait for at least 10 minutes and until the ion pump supply current goes below 100μA. If the tube is not ion pump equipped, wait one hour. Then change the PW to 1000μs. Continue to record the ion pump current and keep the pump turned off if the current is above 1 mA.

CAUTION

If any PA or IPA plate current (Ip) faults occur, or if any crowbars occur during a step after this point, repeat the step during which the fault or crowbar occurred.

NOTE

Whenever the PA is on, perform the following operations every two hours. Also perform these operations five minutes after making any change in the PRF or the PW whenever the PA is on. Observe and record the 7835 tube Ip, Ik, plate voltage (Ep), HV, ion pump current, HV running time meter reading (HVRTM), filament running time meter reading (FRTM), plate water flow, plate inlet water temperature and plate outlet water temperature. After making the listed observations, make and record calculations for input power, output power, dissipated power (using both the water temperature difference method and the Ip versus Ep method) and plate power added efficiency (PAE).

15. Wait for at least 3 hours and until the ion pump supply current goes below 30μA. If the tube is not ion pump equipped, wait 12 hours. Then change the PRF to 15 Hz and the PW to 100μs. Slowly adjust the HV to the lowest possible voltage at or above 28 kilovolts (kV). Reconnect the PA gate "OUT" cable from unit 1181 in rack R03. This will apply plate voltage to the 7835 tube. Adjust the IPA "de-Q-ing" resistance coupling capacitor ("swamping") for a 7835 tube Ik of 400 +/- 5 amps at the center of the pulse.

16. Wait for 15 minutes, then adjust the PA output tuner for maximum PA output power. Readjust the PA input tuner for maximum forward power from the IPA and minimum power reflected back to the IPA. Maintain the PA Ik at 400 +/- 5 amps at the center of the pulse.

CAUTION

If, during any step after this point, the 7835 Ip begins to decrease without any apparent reason (plate current "slumping"), reduce the duty factor (DF) by one-half. Pause for at least two hours and until the ion pump current is below 30μA and the Ip is stable. If the tube is not ion pump equipped, wait for at least 8 hours. If the tube does not improve, check whether cathode emission limiting is occurring. If emission limiting is not the problem, repeat the gas check as in paragraph 2 and contact the RF systems supervisor for additional instructions.

CAUTION

If, during any step after this point, the 7835 output power begins to decrease without any apparent reason (power "slumping"), reduce the duty factor by one-half. Pause for at least two hours and until the ion pump current is below 30μA and the output power is stable. If the tube is not ion pump equipped, wait for 8 hours. If the tube does not improve, check whether cathode emission limiting is occurring. If emission limiting is not the problem, repeat the gas check as in paragraph 2 and contact the RF systems supervisor for additional instructions.

CAUTION

If, during any step after this point, the 7835 plate PAE begins to decrease without any apparent reason (efficiency "slumping"), reduce the duty factor by one-half. Pause for at least two hours and until the ion pump current is below 30μA and the efficiency is stable. If the tube is not ion pump equipped, wait for 8 hours. If the tube does not improve, check whether cathode emission limiting is occurring. If emission limiting is not the problem, repeat the gas check as in paragraph 2 and contact the RF systems supervisor for additional instructions.

CAUTION

If the tube is running well at any step after this point, it may be left running unattended overnight at the PRF and PW for that step. If problems are occurring, such as crowbars, logic trips or high gas periods, contact the RF systems supervisor for instructions and for the DF reduction to be used before leaving the tube unattended overnight.

17. Pause for at least 15 minutes and until the ion pump supply current is below 30μA. If the tube is not ion pump equipped, wait for one hour. Then adjust the HV in small increments to 32 +/- 0.5 kV.

18. Pause for at least 15 minutes and until the ion pump supply current is below 30μA. If the tube is not ion pump equipped, wait for one hour. Then increase the PRF to 30 Hz.

19. Pause for at least 15 minutes and until the ion pump supply current is below 30μA. If the tube is not ion pump equipped, wait for one hour. Then increase the PRF to 60 Hz.

20. Pause for at least 15 minutes and until the ion pump supply current is below 30μA. If the tube is not ion pump equipped, wait for one hour. Then increase the PRF to 120 Hz. Adjust the HV in small increments to achieve an output peak power of 2.5 megawatts (Mw).

21. Pause for at least 15 minutes and until the ion pump supply current is below 30μA. If the tube is not ion pump equipped, wait for one hour. Then increase the PW to 200μs.

22. Pause for at least 15 minutes and until the ion pump supply current is below 30μA. If the tube is not ion pump equipped, wait for one hour. Then increase the PW to 300μs.

23. Pause for at least 15 minutes and until the ion pump supply current is below 30μA. If the tube is not ion pump equipped, wait for one hour. Then increase the PW to 400μs.

24. Pause for at least 15 minutes and until the ion pump supply current is below 30μA. If the tube is not ion pump equipped, wait for one hour. Then increase the PW to 500μs. If the tube PAE is less than 50 percent at this PW or if the plate dissipation exceeds 150 kilowatts (kW), repeat the previous step and then try this step again.

25. Pause for at least 15 minutes and until the ion pump supply current is below 30μA. If the tube is not ion pump equipped, wait for one hour. Then increase the PW to 600μs. If the tube PAE is less than 50 percent at this PW or if the plate dissipation exceeds 180 kW, repeat the previous step and then try this step again.

26. Pause for at least 15 minutes and until the ion pump supply current is below 30μA. If the tube is not ion pump equipped, wait for one hour. Then increase the PW to 700μs. If the tube plate PAE is less than 50 percent at this PW or if the plate dissipation exceeds 210 kW, repeat the previous step and then try this step again.

27. Pause for at least 15 minutes and until the ion pump supply current is below 30μA. If the tube is not ion pump equipped, wait for one hour. Then increase the PW to 800μs. Adjust the PA output tuner for maximum PA output power. Readjust the PA input tuner for maximum forward power from the IPA and minimum power reflected back to the IPA. If the tube plate PAE is less than 50 percent at this PW or if the plate dissipation exceeds 240 kW, repeat the previous step and then try this step again.

28. Pause for at least 15 minutes and until the ion pump supply current is below 30μA. If the tube is not ion pump equipped, wait for one hour. Then increase the PW to 900μs. Adjust the PA output tuner for maximum PA output power. Readjust the PA input tuner for maximum forward power from the IPA and minimum power reflected back to the IPA. If the tube plate PAE is less than 50 percent at this PW or if the plate dissipation exceeds 270 kW, repeat the previous step and then try this step again. The tube is now ready to begin the 150-hour "burn-in" period.

29. Continue to operate the tube for 150 hours elapsed on the HVRTM. If the tube is running well, it can be left unattended overnight. If the tube is having problems, contact the RF systems supervisor for instructions before leaving the tube unattended overnight. If the tube plate PAE drops below 50 percent or if the plate dissipation exceeds 270 kW, reduce the HV for lower tube output power until operation is within limits. Then consult the RF systems supervisor for instructions.

30. At the end of the "burn-in" period, characterize the tube and place it in spares storage.

NOTE

While the tube is in spares storage, brief periodic ion pump current readings shall be made to monitor its condition. These readings must be taken no less frequently than once every two months. A record of these readings shall be kept with the other records for each tube.

31. Table for information: DF at a PRF of 120 Hz as a function of PW.

NOTE

A PRF of 120 Hz corresponds to a pulse repetition period (T) of 8.333 ms. Duty factor is equal to PW divided by T.

Pulse Width		Duty Factor
100μs	0.0120	1.2 percent
200	0.0240	2.4
300	0.0360	3.6
400	0.0480	4.8
500	0.0600	6.0
600	0.0720	7.2
700	0.0840	8.4
800	0.0960	9.6
900	0.1080	10.8
1000	0.1200	12.0

Average power=P_{av}=(delta-T Celsius) 264 (flow gallons per minute)

Peak Power - P_{pk} - P_{av}/DF

ATTACHMENT #2C

Procedure for Installation, RF Processing and Operation of the BURLE 7835 High Power Triode

EXCLUSIVE FOR FERMI NATIONAL LABORATORY

This Application Guide includes general information useful in the care and maintenance, installation and operation of BURLE Tube Type 7835.

A. UNPACKING THE TUBE:

Upon receipt of the 7835 tube, the recipient should visually inspect the shipping crate for damage or other indications of mishandling during shipment. If visual damage is evident, contact BURLE Application Engineering immediately.

After inspecting the crate and contents, cut and remove the metal seals that secure the hasps for the top of the crate. Open the top. Cut and remove the wire threaded through the four wing nuts. Remove the wing nuts.

Connect the lifting hook through the eyebolt provided with the tube. Never lift the tube by any other means than by the lifting device provided. Carefully lift the tube from the crate. When not in use the tube should be stored in the shipping crate only. Store the shipping crate for future use. Lifting the tube requires a crane or hoist having at least a 1,000 lb. rating.

B. TUBE VACUUM TEST:

1. If the tube is supplied with an ion pump, the Purchaser must operate the ion pump at sixty (60) day intervals for as long as necessary to maintain vacuum conditions of less than 20 microamperes of ion pump current.

2. If the tube is not supplied with an ion pump, then a vacuum test should be performed on the tube within thirty (30) days after receipt at the customer's location or sixty (60) days after shipment, whichever occurs first. To perform the Vacuum Test, put a spot knocking supply between grid and cathode and raise the voltage to 2kV. A leakage current of less than 10 microamperes is considered acceptable.

C. TUBE INSTALLATION

1. Make sure all circuit contact areas and ceramic insulators on the tube are clean. All areas of the cavity that make electrical contact to the tube should be checked. If spring finger contact surfaces are dirty or arced, they should be cleaned or replaced before a new tube is installed.

2. Both the upper and lower surfaces of the anode ceramic insulators need to be covered with a mylar protective band before sliding the anode connector assembly over them. The tube ceramic insulators are particularly vulnerable at this time. Never let the connector assembly contacts rub across the ceramic surface. This incidental contact will deposit metal on the ceramic and may cause voltage breakdown problems. The tube ceramics should also be kept free of dust, moisture and other foreign matter.

3. Using the appropriate wrenches make sure the filament connectors on the tube are tight, and that the mating surfaces to the spring rings are clean.

4. Make all the installation measurements of the tube (unless already done since the tube has been received) and of the socket. Record these measurements on the "7835 Installation Data Sheet" and complete the necessary calculations. Adjust the socket dimensions, if required, before installing the tube in the socket.

5. Never force the fit between the cavity mating connectors and the tube terminals when installing the tube. Avoid excessive mechanical stress, particularly on the plate ceramic and filament connectors. If it does not fit properly, stop and determine why.

6. Rotate the tube in a clockwise direction (looking down on the tube) when lowering the tube over the spring rings that make the filament connection. Rotate the tube in the same direction when removing it.

D. PRELIMINARY OPERATING PROCEDURES

In accordance with the Tube Bulletin, make sure that the coolant system is supplying the proper flow of high purity water to all areas and that no leaks exist. The cavity must be pressurized to the recommended pressure, and all protection devices must be checked to insure that they are functioning properly.

E. TUBE OPERATION - BREAK-IN AND SEASONING PROCEDURE

CAUTION: If installed, the ion pump must be turned off only during Step 1 of this procedure and should be operated at all times thereafter. If at anytime the ion pump current exceeds 100 microamperes, stop the procedure and allow the pump to operate until the current is reduced to less than 20 microamperes.

1. Filament Break-In Procedure:

   a. Connect the 7835 in the Gas Test configuration and measure the water leakage current.

   b. Slowly raise the filament current to about 2,000 amps. Allow approximately 5 minutes to elapse before raising the current above the 2,000 amp level.

   c. Raise the filament current in 1,000 amp steps every 2 or 3 minutes until the typical operating level (6,800 amps) is reached.

   d. Allow the filament to operate at this level for about 15 to 30 minutes without anode voltage or drive power to allow time for the getter to pump any released gas.

   <The time for Step 1 is about 30 to 45 minutes.>

2. Perform a Gas Test on the Tube:

   a. After the filaments have been operating at full value for 5 minutes, apply the -45 volt anode voltage.

   b. Turn on the grid supply and adjust for a grid current of 50 amps dc.

   c. Record the initial value of the anode current. After 5 minutes record the final value of the anode current and calculate the final gas current reading which is the anode current minus the water leakage current.

   d. A final gas current value of less than 20 microamperes is acceptable.

   <Typical time for Step 2 is about 15 minutes.>

3. Precaution to be Observed During the Entire Break-In:

   a. During the application of RF drive and plate voltage pulses, observations of the cathode and plate current pulses, the mod block indicator and the ion pump current (if available) are used to judge the progress of vacuum tube clean-up.

   The cathode and plate current pulses and the mod block indicator can be used to judge the frequency of internal tube arcs. Internal tube arcs may increase as the power or voltage applied to the tube is increased. If the tube is operated for a period of time at a constant level of power, the frequency of internal tube arcs will increase, indicating that the normal clean-up is taking place and the power input can be increased to a higher level. An increasing frequency of internal arcs or a burst of internal arcs should be countered by decreasing the power and running at a lower level before again increasing the power.

   If an ion pump is available, it should be used as an indicator of vacuum clean-up Internal arcs usually show up as a short burst or increase in ion pump current. The absence of internal arcs will be accompanied by a decrease in ion pump current.

   Normal outgassing of tube elements after an increase in power will be indicated by a gradual increase in ion pump current. The current will then go through a peak and begin to decrease if normal clean-up is taking place.

If the ion pump current increases rapidly or continues to increase without peaking out, the power should be decreased and break-in completed at a lower level before again increasing power.

4. RF Drive Aging:

a. No plate voltage should be applied to the tube during this portion of the break-in procedure.

b. If at any time during the application of RF drive the driver reverse power becomes unstable or untuneable, reduce the RF drive to a level where the reverse power is stable. This instability is due to a release of gas within the tube as a result of the RF drive.

If the driver reverse power is unstable even at very low levels (less than 2 kW), turn the pulse off and let the tube sit with filaments on for at least four hours before trying again.

c. Apply RF drive at about 10 percent of the normal value (15 kW) for about 30 minutes. If the tube has an ion pump attached, make sure the ion pump current remains below 100 microamps. Increase the drive in 10 percent steps approximately every 15 to 30 minutes until full power is reached.

STEP	POWER	TIME
1.	15 kW	30 minutes
2.	35	15
3.	55	15
4.	75	15
5.	95	15
6.	115	15
7.	125	15
8.	145	15
9.	165	15
10.	175	15

<Typical time for Step 4 is about 3 hours and 15 minutes.>

5. Power RF Operation Break-in Procedure:

a. If at any time during this procedure excessive blocking, crowbarring or arcing should occur, one should reduce the anode voltage until the tube operation is once again stable.

b. Raise the anode voltage slowly until about 10 amperes of peak anode current is reached. Operate at this level for about one hour.

c. Increase the anode current in 10 ampere (peak) steps allowing the tube to operate at each level for about 45 to 60 minutes. Continue this until full power output is obtained. One must periodically check to see if the filament current is set properly for the power being generated.

<Typical time for Step 5 is about 20 hours.>

6. Full Power Seasoning:

a. Allow the tube to operate at full power (3.5 to 5.0 megawatts) for at least 48 hours.

b. Make the final log book entry for the operating parameters of the tube at the conclusion of the break-in period. At the least the following should be recorded.

Filament Current
Forward Power
Reverse Power
Anode Voltage (peak)
Anode Current (peak)
Drive Power

<Typical time for Step 6 is about 48 hours.>

7. The Break-in Procedure Approximate Times:

a.	Filament Break-In	30 minutes
	Gas Test	15 minutes
	RF Drive Break-In....	3 hours, 15 minutes
	Power RF Operation Break-In	20 hours
	Full Power Operation	48 hours
	Total Break-In Time	72 hours

F. PROBLEMS:

If at any time the tube exhibits a serious problem that makes proceeding difficult or impossible, or it appears the tube will not meet specifications, then BURLE Applications Engineering should be contacted for further advice.

G. FERMILAB TUBE TESTING PROCEDURES:

These procedures are those followed by Fermi National Accelerator Laboratory for the testing of a new or rebuilt 7835 vacuum tube. They are acceptable to BURLE, and are appended to the negotiated contract between BURLE and the DOE contracting agencies approving the contract.

ATTACHMENT #5

7835/V1/V2/V3/V4 Warranty and Limitation of Liability

A. NEW TUBE

1. BURLE warrants that the Product at the time of shipment will be ready for RF-processing by Buyer, and when accomplished will provide output at the operating conditions as approved by BURLE Application Engineering.

"Ready for RF-processing" is defined as the Product passing all tests in BURLE's Acceptance Specification 3-1V-7835/V1 Page 6 series. (October 24, 1994) See Attachments #3 and #3A.

BURLE warrants that the Product, upon completion of RF-processing by Buyer, will operate at the above operating conditions for a period of 50 hours, unless an extended warranty is purchased. (See Item 2., below)

If the tube fails to achieve full power, contact BURLE. RF-processing time is defined as the hours during which filament voltage and RF drive signal is applied to the tube to generate power output.

2. Extended Warranty

a. The extended warranty shall consist of the following:

50 hours	Full replacement
1000 hours	Pro-rata
Claim Period:	18 months

b. The applicable operating parameters for the extended warranty are as follows:

Argonne National Laboratory
250 microseconds pulse width, 30 PPS, 2.5 MW peak power output.

Brookhaven National Laboratory
800 microseconds pulse width, 7.5 PPS, 5 MW peak power output.

Fermi National Laboratory
500 microseconds pulse width, 15 PPS, 5 MW peak power output.

Los Alamos National Laboratory
800 microseconds pulse width, 120 PPS, 3 MW peak power output.

3. This warranty applies only if the tube is RF-processed and operated in accordance with BURLE Procedures, (See Attachment #2). If the tube is supplied with a ion pump, during storage or standby either before, during, or after RF-processing, Buyer must operate the ion pump at not greater than sixty (60) day intervals for as long as necessary to maintain optimum vacuum conditions of less than 20 microamperes of ion pump current.

4. For Products purchased without an extended warranty, this warranty shall expire thirteen (13 months after shipment to the Purchaser by BURLE.

5. Said warranty does not apply: i) if the tube has been exposed to unusual or excessive environmental, mechanical, electrical, or thermal stress during the course of RF-processing, installation or use; or, ii) if the operating conditions established by the Purchaser and BURLE Applications are exceeded for any reason including, but not limited to, equipment variations, environment variations, the effects of changes in operating conditions due to variations in device characteristics, improper equipment design, improper device installation or application; or, iii) if tube malfunction is the result of misuse, abuse, improper installation or application, alteration, accident, or negligence in use, storage, transportation or handling, or if the original identification markings on the tube have been removed, defaced or altered.

6. In order to permit BURLE to properly administer this warranty, the Purchaser shall: i) notify BURLE promptly in writing of any claims, and ii) provide BURLE with the opportunity to review the RF-processing and operating records, and to inspect and test the Product claimed to be defective.

BURLE may request the return of the Product, transportation charges prepaid, for more thorough examination. Any such transportation charges paid by the Purchaser will be subsequently reimbursed if the Product is found to be defective due to BURLE responsibility. However, BURLE cannot be responsible for Purchaser packing, inspection, or labor costs in connection with the return. In order to avoid administrative difficulties that result from unauthorized returns, the Purchaser shall request a formal Return Authorization from BURLE before returning Product for any reason. BURLE also requests that the Buyer provide a Return Authorization Service Report (Attachment #4) at the time a Return Authorization is requested.

7. If BURLE's analysis of the returned tube indicates that BURLE is not responsible for the failure to meet the warranty described above, Purchaser will be notified in writing. The Purchaser may purchase a TC&A in order to determine if the tube is a candidate for rebuilding.

8. The liability of BURLE hereunder is solely and exclusively limited to replacement, repair, or credit at the purchase price at BURLE's option for any tube which is returned by the Purchaser during the applicable warranty period and which is found by BURLE to be subject to adjustment under this warranty. IN NO EVENT SHALL BURLE BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES WHETHER IN CONTRACT, TORT OR NEGLIGENCE.

9. BURLE MAKES NO OTHER OR FURTHER WARRANTY, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR WARRANTY OF MERCHANTABILITY.

B. REBUILT TUBE

1. Successful Tube Rebuild

a. BURLE warrants that the rebuilt tube, at the time of shipment, will be ready for RF-processing by the Purchaser, and when accomplished will provide output at the operating conditions as approved by BURLE Application Engineering. Ready for RF-processing is defined as the tube passing all tests in BURLE's Acceptance Specification 3-1V-7835/V1, Page 6 series.

b. This warranty applies only if the tube is RF-processed and operated in accordance with BURLE Procedures (See Attachment #2).

If the tube is supplied with a ion pump, during storage or standby either before, during, or after RF-processing, the Purchaser must operate the ion pump at not greater than sixty (60) day intervals for as long as necessary to maintain optimum vacuum conditions of less than 20 microamperes of ion pump current.

BURLE warrants that the rebuilt tube, upon completion of RF-processing by the Purchaser, will operate at the above operating conditions (see paragraph 2, subsection b of the extended warranty for new tubes) for a period of 5 hours to verify the integrity of the rebuild.

For tubes rebuilt without an extended warranty, this warranty shall expire thirteen (13) months after shipment to the Purchaser by BURLE.

2. Rebuilt Tube Not Accepted

a. If the Product fails to achieve full power, contact BURLE at once. BURLE may request the privilege of sending a representative to the site in order to verify the operating parameters of the tube. If BURLE agrees that the Product will not pass acceptance, it will be returned to BURLE for analysis.

If the analysis indicates the Product failed due to materials or workmanship provided by BURLE, the Purchaser will not be invoiced and/or credit will be issued for the rebuild task. At this point, BURLE obligation ceases for this rebuild. If the Product can be rebuilt, a new quote will be submitted to the Purchaser.

If, on the basis of BURLE's analysis, the Product failed due to customer-supplied materials that were not completely replaced or renewed by BURLE, Purchaser will be invoiced at 80% of the selling price of the repair task for repairs R3 and higher. (For ease of computation, this is approximately equivalent to 100% of the break-even cost of the repair task). Subsequent analysis and rebuilding will be requoted by BURLE for the Purchaser's consideration. For rebuilds R1 and R2, the Purchaser will be invoiced at 70% of the selling price of the repair task. (For ease of computation, this is equivalent to 85% of the break-even cost of the repair task). Subsequent analysis and rebuilding will be requoted by BURLE for the Purchaser's consideration.

b. Said warranty does not apply: i) if the tube has been exposed to unusual or excessive environmental, mechanical, electrical, or thermal stress during the course of RF-processing, installation or use; or, ii) if the operating conditions stated in A.1, above, are exceeded for any reason including, but not limited to, equipment variations, environment variations, the effects of changes in operating conditions due to variations in improper equipment design, improper device installation or application; or, iii) if tube malfunction is the result of misuse, abuse, improper installation or application, alteration, accident, or negligence in use, storage, transportation or handling, or if the original identification markings on the tube have been removed, defaced or altered.

c. In order to permit BURLE to properly administer this warranty, the Purchaser shall: i) notify BURLE promptly in writing of any claims, and ii) provide BURLE with the opportunity to review the RF-processing and operating records, and to inspect and test the Product claimed to be defective.

BURLE may request the return of the Product, transportation charges prepaid, for more thorough examination. Any such transportation charges paid by the Purchaser will be subsequently reimbursed if the tube is found to be defective due to BURLE responsibility. However, BURLE cannot be responsible for Purchaser packing, inspection, or labor costs in connection with the return. In order to avoid administrative difficulties that result from unauthorized returns, the Purchaser shall request a formal Return Authorization from BURLE before returning tube for any reason. BURLE also requests that the Buyer provide a Return Authorization Service Report (Attachment #4) at the time a Return Authorization is requested.

d. If BURLE's analysis of the returned tube indicates that BURLE is not responsible for the failure to meet the warranty described above, Purchaser will be notified in writing and invoiced for the full price of the rebuild Task. The Purchaser may purchase a T,C&A in order to determine if the tube is a candidate for rebuilding.

e. The liability of BURLE hereunder is solely and exclusively limited to credit at the repair Task price for any tube which is returned by the Purchaser during the applicable warranty period and which is found by BURLE to be subject to adjustment under this warranty. IN NO EVENT SHALL BURLE BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES WHETHER IN CONTRACT, TORT OR NEGLIGENCE.

BURLE MAKES NO OTHER OR FURTHER WARRANTY, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR WARRANTY OF MERCHANTABILITY.

Attachment #6

Government-Furnished Property

This manifest is a summary of all known Government-furnished equipment which is currently provided to BURLE INDUSTRIES by Fermi National Laboratory and The United States Department of Energy for use in the remanufacturing process of RF power tubes used by the DOE National Laboratories.

Item	Quantity (each)	Description	Identification Number
~~1~~	~~1~~	~~Furnace~~	~~AF290144~~
2	1	Hoist, 1000#	91016-000105

Attachment #7

Product Descriptions

PRODUCT ID	PRODUCT DESCRIPTION
Type 7835 Family	
Type 7835	Water-cooled Large Power Triode
Type 7835V1	Same as Type 7835, except Connector Plugs have been removed
Type 7835V2	Type 7835V1 with one (1) Physical Electronics Item #648263, 2 L/S Ion Pump
Type 7835V4	Type 7835V1 with two (2) Physical Electronics Item #648263, 2 L/S Ion Pumps
Type 4616 Family	
Type 4616V4	Water cooled Beam Power Tetrode for use at frequencies between 195 and 600 MHz
Type 4616V8	Type 4616V4 for use at frequencies between 150 and 190 MHz
Type 7651 Family	
Type 7651	UHF Beam Power Tetrode]