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The Zetatron Neutron Tube and Pulse Transformer for Driving It - A Transfer of Technology to the Private Sector

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THE ZETATRON NEUTRON TUBE AND
PULSE TRANSFORMER FOR DRIVING IT --
A TRANSFER OF TECHNOLOGY TO THE PRIVATE SECTOR

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I. INTRODUCTION

Sandia Laboratories Contract 07-5363 was initially released for quotation (JWR/07-5368) on December 23, 1977. Seven (7) companies requested and received copies of the RFQ. Firm proposals were received from four of the seven companies. Technical evaluations were completed and Kaman Sciences Corporation, Colorado Springs, Colorado, selected as the successful bidder. Contract 07-5363 was awarded on May 5, 1978, with funding of \$320,689.00 for the completion of Phases I through IV. This report covers the results of Kaman's efforts on Phases I and II which were completed on September 30, 1979.

The purpose of this procurement is to develop a commercial supplier capable and willing to supply neutron tubes and tube-transformer assemblies to the commercial market for use in logging probes for uranium exploration. The fabrication of neutron tubes is defined under Phases I and III of the contract; the fabrication of test-transformer and tube-transformer assemblies are defined under Phases II and IV. The work was scheduled in this manner to permit the incorporation of advanced tube and tube-transformer design in Phases II and IV.

Phase I required the fabrication of ten (10) Zetatron tubes with subsequent delivery to Sandia Laboratories for electrical testing. Limited testing was performed by Kaman which included testing of the reservoir, a leak test of the completed tube, and a leakage current test of the high voltage insulator. The vendor was supplied preloaded reservoir and target assemblies from the General Electronic Neutron Devices Department (GEND), Pinellas, Florida. All piece part fabrication, fixture design and assembly was completed by Kaman with technical support provided by Sandia as requested.

Phase II required the vendor to fabricate five (5) test transformers and perform an operational life test on three (3) of them. In addition, the fabrication of three (3) tube-transformer assemblies using tubes supplied by Sandia was required. Subsequent operational life testing of the TTA's (Tube-Transformer Assemblies) and the two remaining test transformers was performed by Sandia Laboratories.

II. TECHNICAL PERFORMANCE

A. Phase I (Zetatron Tubes)

A total of ten (10) completed tubes were specified for delivery under this phase of the contract. Kaman started with sufficient piece parts to assemble 20 tubes. A total of 13 preloaded targets and reservoirs were supplied by GEND

during Phase I. Assembly and processing experience was excellent, with a total of 12 tube assemblies built to provide ten (10) acceptable tubes. The two reject assemblies occurred as a result of using reservoirs and targets that had been air exposed and oxidized during shipment. The following table provides test results at one input condition (target voltage of 100 kv, source current of 1 A) so a comparison of the reproducibility of the ten tubes can be made.

TUBE #	RESERVOIR CURRENT (A)	TUBE CURRENT (ma)	OUTPUT $10^8 \times \text{sec}^{-1}$
101	3.9	120	2.18
102	3.8-3.9	150	3.19
103	3.8	140	2.66
104	4.7	150	2.16
105	4.4-4.5	180	2.12
106	4.5	150	2.38
107	4.6	120	2.19
108	4.0	90	.86
109	4.2	65	.86
110	4.5	80	.85

An unacceptably wide range of reservoir operating currents was observed. The last three tubes, 108, 109, and 110 were operated using a new source and target driver. Uncertainty regarding the calibration of input drive voltages remains to be resolved. The results of tests performed at Sandia on the operational characteristics of these tubes are shown in Figures 1 through 10.

FIGURES 1-10. Neutron output rate (OP) and tube current (I_t) as a function of ion source current (I_s). Tube current plotted with dashed lines, neutron output rate with solid lines.

FIGURE 2.

FIGURE 3.

FIGURE 4.

FIGURE 5.

FIGURE 6.

FIGURE 7.

FIGURE 8.

FIGURE 9.

FIGURE 10.

B. Phase II (Test Transformers)

Kaman completed the fabrication of five (5) test transformers and delivered two of them to Sandia for life testing. As of this date, the Sandia tests are incomplete. One transformer received approximately 100,000 operations into a resistive load before the pulse forming network SCR latched on and, because of improper limiting of the power supplies, destroyed the test station drive circuitry. This occurred at that point in time between testing of tubes #107 and #108 which necessitated the use of a new driver for subsequent tests as noted in Section A above.

Operational life testing of three test transformers was conducted by Kaman. These tests were performed into a 600 kW resistive load at 100 pps (pulses per second), at a nominal output voltage of 115 kV. Transformer #2102 completed 80 hours of operation without failure and was shipped to Sandia for further test. Transformers #2104 and 2105 both failed due to high voltage punctures through the potting to the ground plane. Transformer #2104 failed after 30 hours of operation and #2105 failed during the 12th hour.

C. Phase II (Tube-Transformer Assemblies)

Kaman delivered three (3) Tube Transformer Assemblies using tubes supplies by SLA for this purpose from the Phase I build. As of this date, no tests have been performed on those TTA's. It is anticipated that Department 2354 will begin the TTA tests during January, 1980.

III. CONTRACT 007-5363

Due to its length (23 pages) the contract is included in this report by reference only. A complete copy of the contract is maintained in the files of Division 2354 and of course, in the Sandia Laboratories Purchasing Department.

IV. MONTHLY PROGRESS REPORTS

In accordance with the contract, Kaman was required to submit monthly progress reports during the course of the work. These reports are included herein by citing the dates of the reports. Copies of the actual reports are maintained in the files of Division 2354.

June 20, 1978	February 19, 1979
July 28, 1978	March 20, 1979
August 16, 1978	April 20, 1979
September 11, 1978	May 21, 1979
October 18, 1978	June 20, 1979
November 20, 1978	July 20, 1979
December 20, 1978	August 20, 1979
January 19, 1979	November 27, 1979

V. SANDIA FURNISHED EQUIPMENT

The following is a tabulation of equipment furnished Kaman by Sandia Laboratories through September 30, 1979, in support of this contract.

<u>QUANTITY</u>	<u>DESCRIPTION</u>
1 Ea.	Magnet (Dwg. 322474-200)
2 Ea.	Target Pulse Transformer
1 Ea.	Source Pulse Transformer
1 Ea.	Lead Probe (U 3669)
1 Ea.	Power Supply
1 Ea.	Integrator Chassis
1 Ea.	Scaler Chassis
2 Ea.	Temporary Potting Molds
2 Ea.	Mold Inserts
2 Ea.	Honeywell Elektronik III Recorders-Controllers
2 Ea.	200 μ /sec. Ion Pumps S/N 216350 (1 has no S/N)
2 Ea.	Ion Pump Controllers S/N 216795 (1 has no S/N)
1 Ea.	Autovac Gauge Controller Type 3294B
2 Ea.	Vac-Sorb Pumps and Dewars
10 Ea.	Granville-Phillips Gold Seal Valves
2 Ea.	Sliding Rails
2 Ea.	Power Supply Model HV1565
1 Ea.	Test Control Panel
1 Ea.	Integrator, Model U-7354 S/N 008
1 Ea.	Scaler, Model U-7353 S/N 010
1 Ea.	Lead Probe S/N JD009
1 Ea.	Autovac Gauge Controller S-144714
1 Ea.	Ultek Ion Pump Supply S-151818, S-151819
1 Ea.	Ultek Ion Pump S-151817
1 Ea.	Honeywell Controller/Recorder

<u>QUANTITY</u>	<u>DESCRIPTION</u>
4 Ea.	Sorption Pump Heaters
1 Ea.	Instrument Cabinet
1 Ea.	Vacuum Furnace, Sandia Built
1 Ea.	Astro H ₂ Furnace Model APF-0716-1600MS
1 Ea.	Vapor Hone Model 1818
1 Ea.	Precision Coil Winder, Geo. Stevens
1 Ea.	Vertical Flow Laminar Bench
1 Ea.	Furnace, Model 51442 With Controller, Model 59344
1 Ea.	HBS Dumatic 500 Electro Polisher
1 Ea.	Hewlett Packard Model 8011A Pulse Generator
1 Ea.	Hewlett Packard Model 6448B Power Supply
1 Ea.	Hewlett Packard Model 6282 Power Supply
1 Ea.	Hewlett Packard Model 6516 Power Supply
1 Ea.	Varian Mass Spectrometer Head, Model VGA100

VI. SANDIA FURNISHED MATERIAL

The following is a tabulation of material furnished Kaman by Sandia Laboratories through September 30, 1979, in support of this contract, including items purchased by Kaman.

<u>QUANTITY</u>	<u>DESCRIPTION</u>
3 Ea.	Neutron Tubes (from Phase I)
4 Ea.	Glass Section 24" Lengths
8 Ea.	Glass Cylinder (Dwg. 323804-200)
30 Ea.	Cylinder (Dwg. 322483-201)
30 Ea.	Cylinder (Dwg. 322483-202)
60 Ea.	Cylinder (Dwg. 322483-200)
30 Ea.	Insulator (Dwg. 322456-200)
13 Ea.	Reservoir Assy., Preprocessed (Dwg. 327762-200)
30 Ea.	Disc. (Dwg. 325483-200)
30 Ea.	Feed-Thru (Dwg. 325486-200)
13 Ea.	Target, Processed (Dwg. 325479-200)
2 Ea.	1.6 h Chokes

VII. CONCLUSIONS

The fabrication, testing, and delivery of ten (10) Zetatron tubes under Phase I of Contract 07-5363 was successfully completed by Kaman Sciences Corporation. Twelve (12) starts were required to complete ten (10) acceptable tubes. This is an excellent performance record for first-fabrication attempts of a tube design that was new to Kaman Sciences Corporation.

The fabrication of test transformer and tube-transformer assemblies required under Phase II of the contract was satisfactorily completed. Testing of these components is still in progress.

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