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# Continuing Search for a New Type Charging Belt

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## ABSTRACT

As reported at the 1994 Symposium of North Eastern Accelerator Personnel, a search was made for a new type of charging belt for the ORNL EN Tandem. Final results of the first belt tested, lessons learned, and progress with a still different belt is discussed.

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### 1. Background

The EN Tandem accelerator at Oak Ridge National Laboratory (ORNL) operates to support a varied program of atomic physics research. As such, the demands on the accelerator often require a range of operation from ~0.38 to 7.0 MV on the terminal, with low ripple and long term steady state operation. The standard charging belts obtained from the manufacture have generally given acceptable performance, but it is reasonable that modern manufacturing techniques and materials could increase belt lifetimes and improve accelerator performance, particularly voltage ripple.

A new belt of significantly different construction from that of the conventional belts was specified, purchased, and installed in 1993. After 2800 hours of use at voltages from 0.38 to 5.8 MV, it was removed from the accelerator in early August 1995.

### 2. Experimental Belt #1

The first belt tested was manufactured by Ammeraal Inc. of Grand Rapids, Michigan. An order was placed for a 9.0964 m long, 528 mm wide belt type 109 of endless woven (GK) polyester with .5 mm top and .3 mm bottom coatings of Ropanyl - a trade name for urethane.

Urethane was selected for various reasons detailed in the past proceedings of this body. At the time of specification of the belt material, however, a severe oversight was made. The Ropanyl urethane product used for the belt cover has a maximum product contact temperature of 195° F. Due to the high temperature of the charging corona plasma, the surface layer of the cover was melting. It then either formed a rough surface on the belt or flew from the belt to be deposited in the machine. This caused progressive degradation of the volume resistivity of the belt, and eventually it was electrically punctured in one spot. This increased the ripple and made charging power supply regulation impossible. Although a 2800 hour lifetime is considered short by accelerator standards, it is not altogether irrelevant to consider that this is ~168,000 miles of travel. The carcass had stretched to its ultimate length, and the belt was tracking nicely.

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Valuable lessons were learned from the belt after its removal from the machine. The initially snowy white belt was marked by the harsh environs to which it had been subjected. It revealed scars from sparks, melting of its outer cover, puncture and subsequent effects of that wound, and normal marking from life in an accelerator that the old black belts had hidden from view.

### **3. Experimental Belt #2a**

A new belt was ordered in late December 1994 with a .5 mm top cover of Ropan, and .3 mm bottom cover of Ropanyl. Ropan is a different urethane product with ~700° F product contact rating. It is a harder, tougher material and should have even better wear characteristics. Inspection of the inside of the Ropanyl belt revealed no damage and, since it was a softer, more compliant product, it was retained as the inner covering.

Included in the specifications for the belt were shipping specifications that required all bends to be of a radius greater than 25 cm. When the belt arrived in February, it was obvious that it had been rolled as tightly as possible for shipment. The belt was stored and then removed from its shipping container in July. There were several tight kinks in the belt. After installation in early August, it was immediately obvious that the kinks were going to cause severe problems. The charging and charge removal shims could be seen and heard slapping the belt as they were bounced by the traveling kinks. A call was made to the manufacture who stated that the kinks would probably not come out with time and tension. They promised to replace the belt as soon as the factory in The Netherlands could produce it.

Much of the interim time was used in cleaning Ropanyl residue from the column. A great aid in this task was the use of rods, brushes, and coils sold for the cleaning of firearms. With several bright lights, a blow gun connected to 100 psig air, and various tools to scrape, scrub, and polish, the high energy column was diligently cleaned.

### **4. Experimental Belt #2a**

The replacement belt was received three weeks later and immediately installed. Although some small amount of care had been taken to use mandrels to increase the radius of the bends in shipment, they were still too small. Also, the belt was shrink wrapped with one wrap passing over the ends, which kinked it down over the too-short rough wooden mandrels. The outer Ropan surface seemed to have some bubble holes causing it to appear porous. The construction quality of this belt was poor in comparison to the previous two. It would have been rejected had there not been the urgency to return the accelerator to operation.

## 5. Installation and Testing

The belt installed easily and tracked well. It stretched quite a bit each time it ran, requiring frequent retensioning. Early fluttering decreased and, after one day of intermittent running in, the shims were installed and charge carrying capacity tested.

Charge was slowly increased to the terminal that was shorted to ground through current meters and an oscilloscope. An initial large negative self charge was corrected by changing internal shim positions, and the ripple looked reasonable. Mechanically, the belt flapped little and tracked very well vertically.

## 6. Early Operational Experience

Initially only 70 psig of gas was transferred to the accelerator and a shorted terminal test was made. Over 400  $\mu\text{A}$  could be transferred to the terminal. Eight kilovolts were required to transfer 300  $\mu\text{A}$  to the terminal. The machine was turned over to researchers for early low voltage runs as the gas was dried and the belt continued to stretch.

Early this month (October 1995), gas was added to increase to accelerator tank pressure to 87 psig, with 28 ppm  $\text{H}_2\text{O}$ . The machine was conditioned to 6 MV with about 20 tank sparks. Belt tension adjustments have been made since closing the tank that account for 1/2 inch of elongation. Vertical tracking, as observed on the drive motor at the high energy end, appears very steady. Terminal ripple measured at 3 MV with the terminal potential stabilizer in slit, or GVM control is  $\sim 700$  volts RMS total for the range 0 to 50 hertz. Charge balances are reasonable. Unregulated terminal ripple at 6 MV was  $\sim 5$  kilovolts RMS, as compared to over 16 kilovolts with a conventional belt.

## 7. Very Early Conclusions

The ORNL EN Tandem must be flexible in operation to satisfy the requirements of researchers for low (0.38-5.0 MV) voltage very stable operation for many experiment programs, and the occasional short duration high (5.0-7.0 MV) voltage run. This belt gives early indication that it may fill both requirements. Conditioning beyond the present 6.0 MV point will await experimental requirements that justify the addition of gas. Early ripple characteristics are encouraging, and appear to be improving with time.

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