

# HIGH-POWER TEST OF THE SDTL FOR THE JAERI/KEK JOINT PROJECT

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## Abstract

The separated DTL (SDTL) which accelerates a  $H^-$  ion beam from 50 to 190 MeV is one of the main components in the injection linac for the JAERI/KEK joint project. The resonant frequency is 324 MHz. It consists of 32 independent tanks. The first two tanks of the SDTL were constructed. The tank cylinders are made with the newly established copper electroforming method on the steel. The high power conditioning of SDTLs has been completed successfully. The maximum input peak-power was about 500 kW, which is approximately three times of the required power. The repetition rate of the rf pulse is 50 Hz and the pulse length is 600  $\mu$ sec. The time we spent for the conditioning for each tank is about 30 hours. The required conditioning period is extremely short.

## 1 INTRODUCTION

The construction of a high-intensity proton accelerator facility, proposed by the Japan Atomic Energy Research Institute (JAERI) and the High Energy Accelerator Research Organization (KEK), has been started at Tokai campus of JAERI. The accelerator consists of a 400-MeV linac, a 3-GeV rapid cycle synchrotron and a 50-GeV synchrotron. The 400-MeV injection linac is comprised of the a  $H^-$  ion source, an RFQ, a drift-tube linac (DTL), a separated DTL (SDTL), an annular-coupled structure (ACS) linac and several beam transport lines.

The separated DTL (SDTL) has been designed as the accelerator following the Alvarez DTL. The SDTL has no focussing quadrupole in the drift tube. Instead, the doublet quadrupole magnet is set between the adjacent tanks of the SDTL. Thus the drift tube has much smaller radius than that of the DTL for increasing the shunt impedance [1]. Schematic view of the SDTL is shown in figure 1.

The SDTL consists of 32 independent tanks. The first two tanks of the SDTL has been constructed and tested by the high-power rf. The tank assembling data and the results of the rf measurement for the SDTL-1 and -2 are described in the following sections.

## 2 STRUCTURE

The SDTL tank has five accelerating gaps (5 cells). Namely the SDTL tank has four full size drift tubes (DTs) in the tank cylinder and two half size DTs on both end-plates. The inside diameter of the tank is 520 mm. The tank

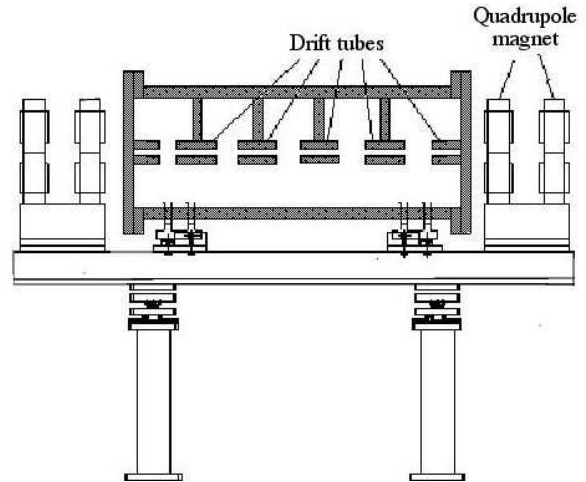


Figure 1: Schematic view of the SDTL.

length is 1479.4 mm for SDTL-1 and 1531.4 for SDTL-2, respectively. SDTL-32 is the longest tank, which is 2559.3 mm in length. The drift tube is 90 mm in outside diameter and the bore is 30 mm in diameter.

For SDTL-1 and -2, each tube has been aligned on the beam axis by using an optical alignment telescope within the error of  $\pm 0.1$  mm for x-y plane and  $\pm 0.2$  mm for z-axis. Measured position for the DTs are shown in figure 2.

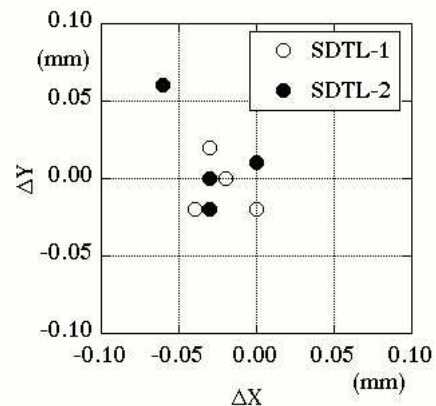


Figure 2: DT position.

The SDTL tank has two fixed tuners and a movable tuner. The former is used for adjusting the frequency to 324 MHz and flattening the accelerating field.

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Inside surface of the SDDL tank is formed by the periodic reverse (PR) copper electro-forming method [2], which was already applied to our Alvarez DTL. The basic properties have been confirmed by the high-power model tank successfully [3]. The number of the copper layers of the electroforming for the Alvarez DTL is two.

Standard fabrication process of the electroforming is following:

- (1) pre-processing on the inner surface of the iron cylinder for the followed electroforming;
- (2) first PR copper electroforming ( 0.5 mm);
- (3) lathing the copper surface ( 0.2 mm);
- (4) 2nd electroforming;
- (5) lathing;
- (6) finishing by the electropolishing ( 50  $\mu$ m), of which the depth has been chosen in order to get the better surface condition.

The high performance of the double layered surface has been already proved by the high-power test of the model tank of the DTL. However, mono layered electroforming has been applied to the SDDL 2nd tank (SDDL-2) for decreasing the fabrication cost of the tank, while the SDDL-1 has double layers of the PR copper electroforming for comparison.

### 3 RF PROPERTIES

The unloaded Q-value of the SDDL tank cylinder without the DT has been measured for the  $TM_{010}$  mode. Results are summarized in table-1. Both the measured Q-values are approximately 93 % of the calculated one.

Table 1:  $Q_0$  of  $TM_{010}$  mode for SDDL tank cylinder.

Tank No.	measured (calculated)	frequency (MHz)
SDDL-1	65890 (70247)	440.703
SDDL-2	65740 (70503)	440.690

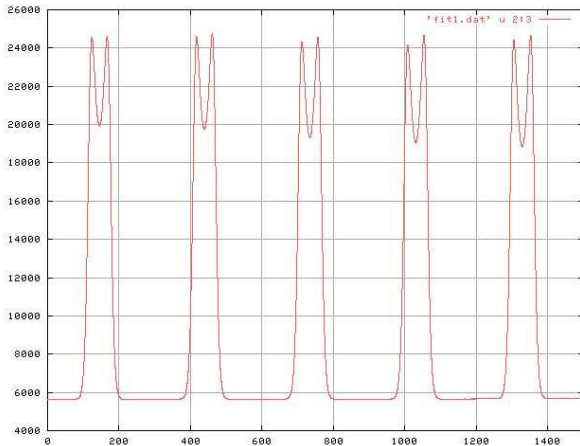


Figure 3: Measured electric field on the beam axis.

An electric field on the beam axis has been measured by the bead-pull perturbation method. The field distribution for SDDL-1 is shown in figure 3. Maximum variation of the average field in each cell of SDDL-1 is about 1%, which has been achieved by the adjustment of the fixed tuners.

The calculated shunt impedance for the SDDL-1 ( $Q_0 \sim 41300$ ) requires the input power of approximately 170 kW for obtaining the 2.5 MV/m field on beam axis.

### 4 HIGH-POWER CONDITIONING

A high-power conditioning has been done for the SDDL-2 at first, which has mono copper layer on the inner surface. The conditioning of the SDDL-1 has been followed. The conditioning history for both SDDL-1 and -2 are shown in figures 4 and 5 respectively.

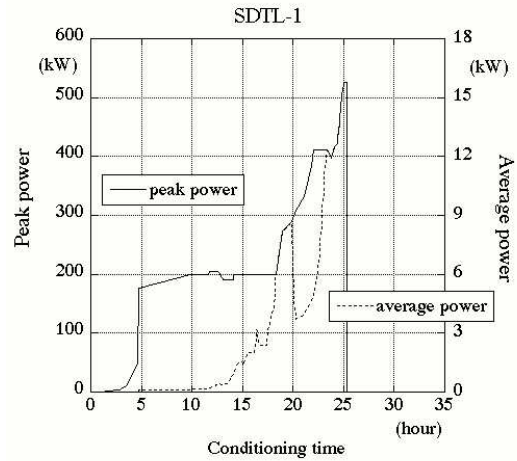


Figure 4: Conditioning history for SDDL-1.

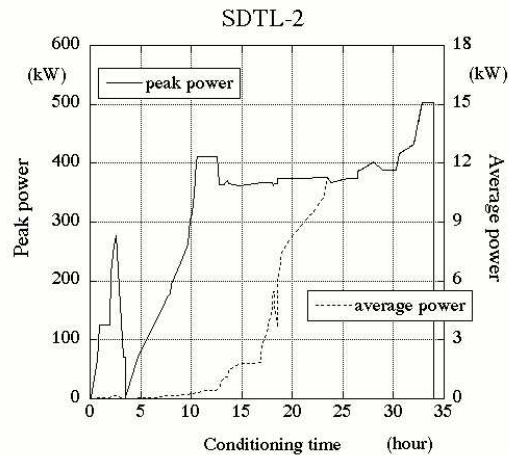


Figure 5: Conditioning history for SDDL-2.

The conditioning has been started after the tuning of the system. The rf conditioning was started with a short pulse ( 100  $\mu$ sec ) and a low repetition rate ( 10 Hz ). The input peak power was increased gradually up to the design value for the tank. The rf duty factor then has been extended to the maximum value of 3% ( 600  $\mu$ sec in the pulse length, 50 Hz in the repetition rate ). The duty factor was reduced again when the power level went beyond the design value and it reached up to 3% at the maximum power level, which is limited by the radiation safety and for avoiding the risk of the discharge in the tank. The maximum input power was about 500 kW, which is approximately three times the design value and quite high for the conditioning.

The clear evidence, which shows the difference due to the number of the electroformed copper layers, has not been observed for the conditioning of SDTL-1 and -2. We have decided on the basis of the result that the mono layer of copper electroformed surface is sufficient for the SDTL tank.

## 5 INPUT COUPLER

RF power is fed into the tank through the input coupler with ceramic window. Two types of the coupler have been developed for the DTL and SDTL. The designs are shown in the figure of reference [3].

The coupler for the DTL has the ceramic window on the tank wall and a movable loop for changing the coupling to the tank is located outside of the window. Another one for SDTL has the coaxial ceramic window and the fixed loop at the tank wall in vacuum.

Both couplers have been used for the high-power conditioning of the SDTL without any problem. Because the maximum input power (  $\sim$ 500 kW, 50 Hz, 600  $\mu$ sec ) is not enough for the coupler test, the test stand for the coupler, which does not use the SDTL tank, is planned.

## 6 SCHEDULE

Next 10 SDTL tanks ( No. 3 to 12 ) will be assembled at the end of this year at KEK. The conditioning of each tank will be started immediately after the assembling of the tank. The manufacturing process of the SDTL tanks (No. 13 to 32) has been started. The first one will be completed in 2003.

## 7 REFERENCES

- [1] T. Kato, KEK Report 92-10 (1992)
- [2] H. Ino, et al, "Advanced copper lining for accelerator components", Proc. of LAC 2000, California, USA, 1015 (2000)
- [3] F. Naito, et al, "Development of the 50-MeV DTL for the JAERI/KEK joint project", Proc. of LAC 2000, California, USA, 563 (2000)