5 MW 805 MHz SNS RF System Experience

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Introduction

RF System for the 805 MHz normal conducting coupled cavity linac of SNS:

- Designed, procured and tested and LANL
- Installed and commissioned at ORNL
- Four pulsed 5 MW klystrons operating with a pulse width of 1.25 ms and 60 HZ repetition frequency.
- The RF power from each klystron is divided and delivered to the CCL through two windows.
- Each klystron has a circulator and a circulator load capable of accepting a full reflection at any phase.

AFT 5 MW Circulator

The SF_6 System

Vacuum Leak Checking a Circulator

- The circulators were filled with SF_6 gas to prevent RF breakdown.

- They were leak checked at 100 mTorr to verify no vacuum leaks before filling with SF_6.

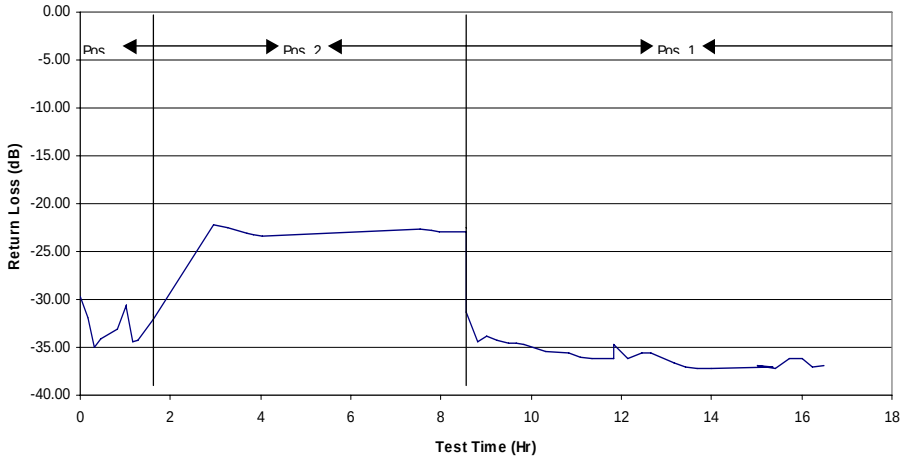
- Kapton windows were used as a gas barrier.

AFT 5 MW Circulator

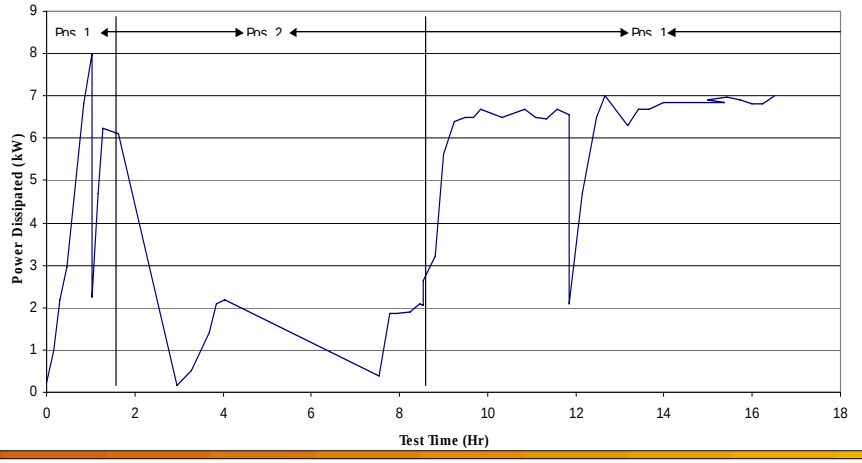
High Power Test Results

- 12 circulators were ordered and 5 were high power tested and installed on the CCL.
- The circulators were high power tested to 5 MW into a matched load.
- The circulators were tested to 5 MW peak power (60 Hz, 1.25 ms) into a short at three phases: The highest power dissipated in the circulator, the highest electric field in the circulator, and a intermediate phase.
- A four hour heat run was completed at the phase with the highest arc rate.

Return Loss versus Test Time



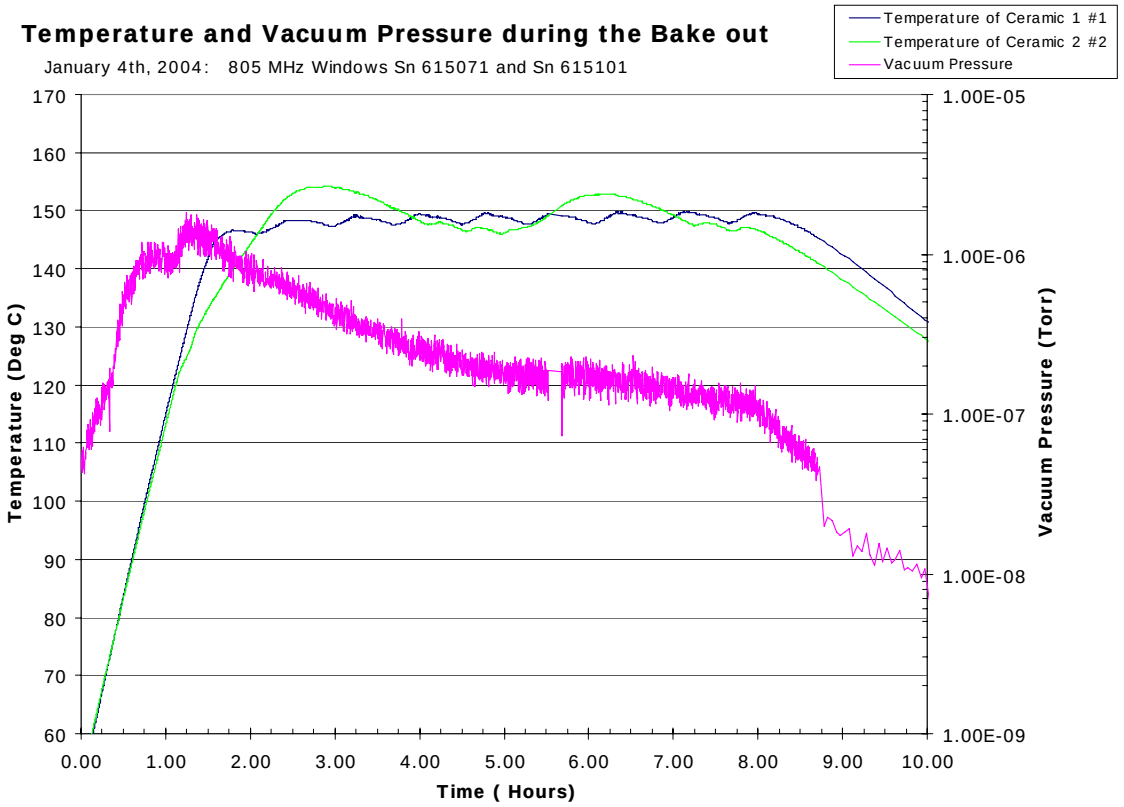
Power Dissipated in the Circulator versus Test Time



Thales 2.5 MW Windows

High Temperature Bake Out

- The windows were baked out to between 150 degrees C and 200 degrees C until the vacuum pressure decreased below 5E-7 Torr.



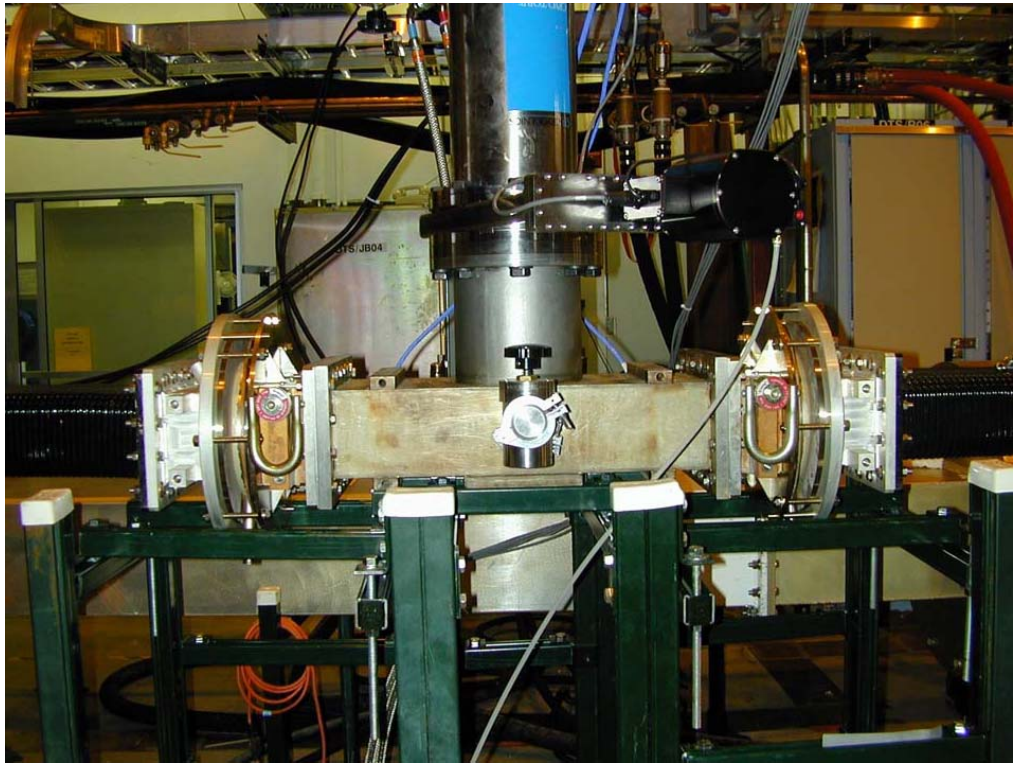
Thales 2.5 MW Windows

High Power Test Results

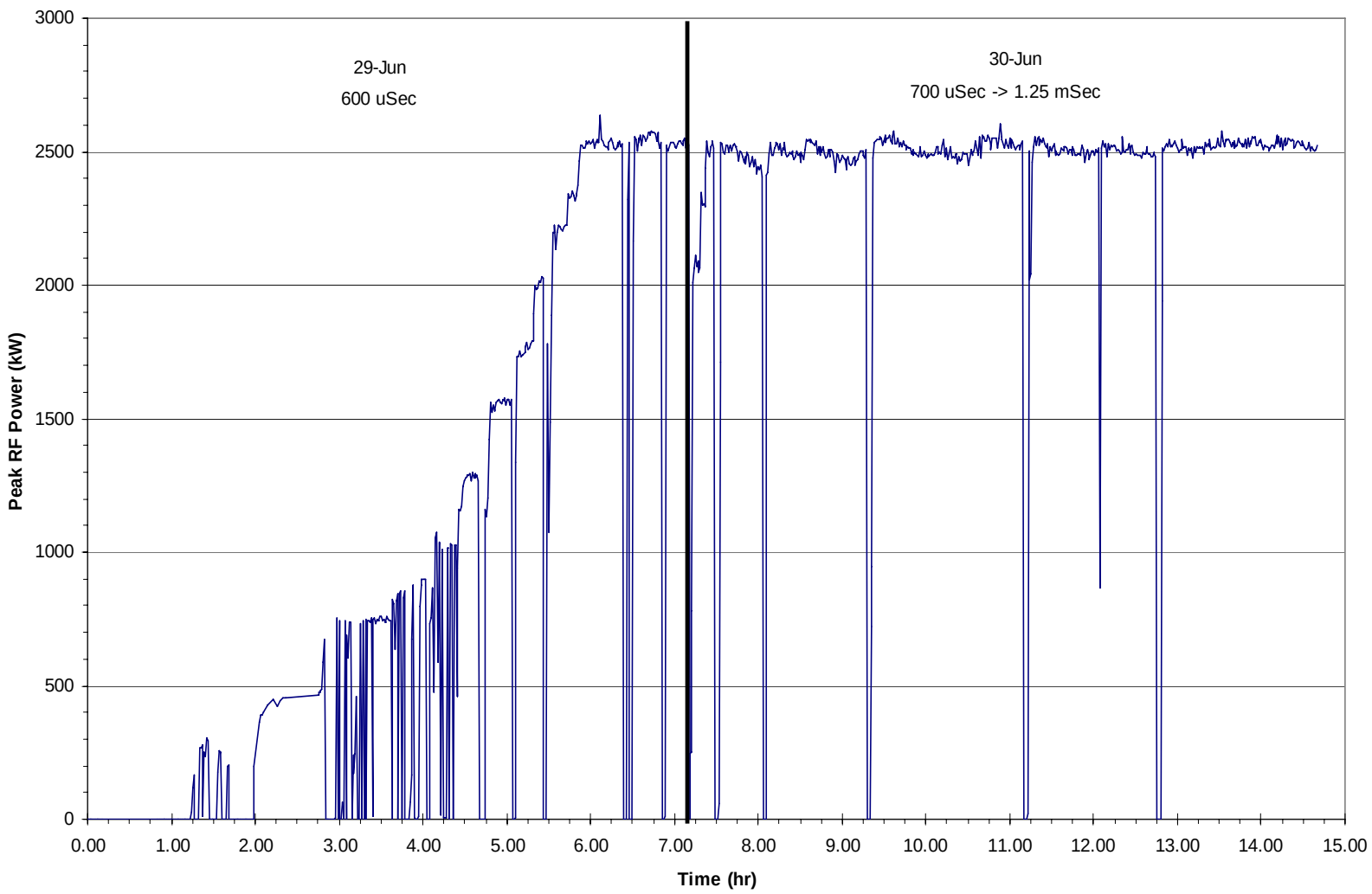
•12 windows were ordered and 8 were high power tested and installed on the CCL.

• Windows were conditioned to 2.5 MW peak power at 1.25 ms pulse width and 60 Hz repetition rate. A four hour heat run was done at full power.

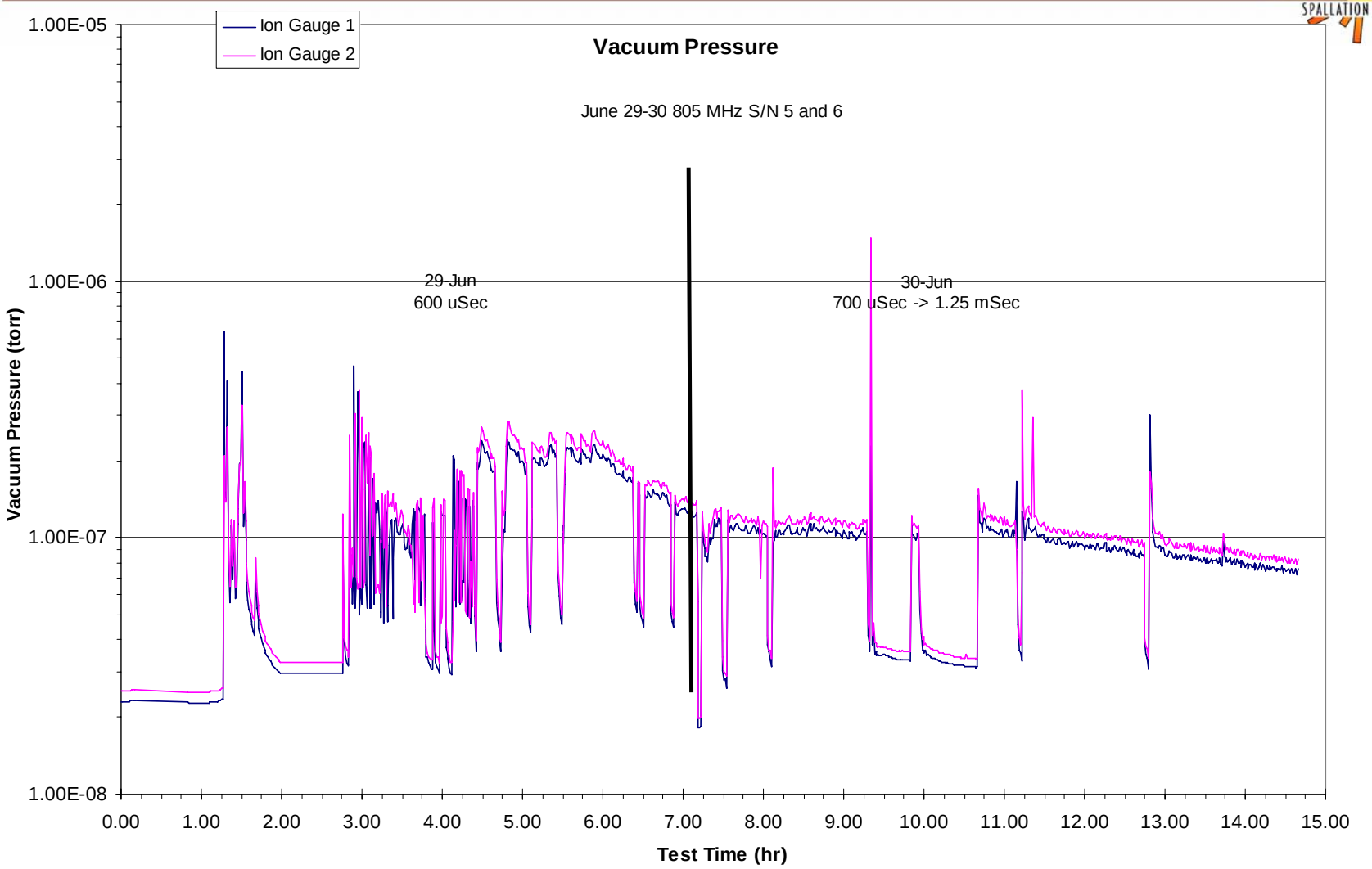
• Windows were tested for high peak power at 2.5 MW peak forward power into a short with a 100 µs pulse width. This is equivalent to 10 MW peak power into a matched load.



Thales 2.5 MW Windows



Thales 2.5 MW Windows



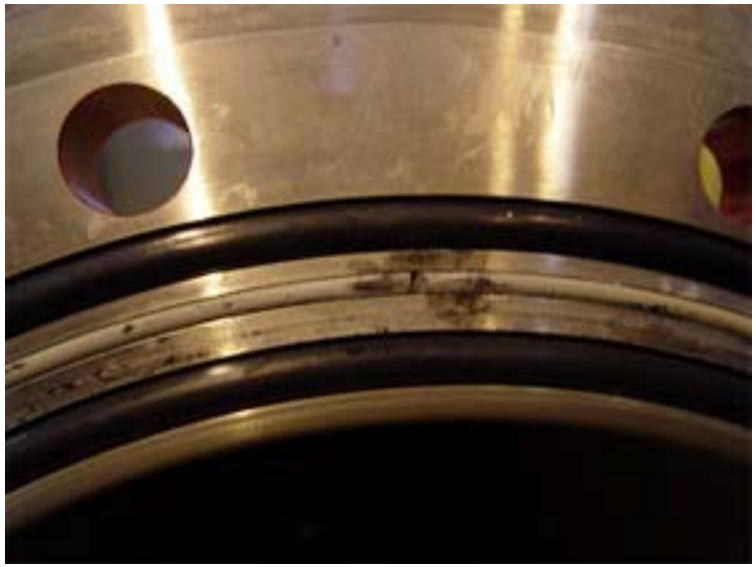
SureBeam 5 MW Loads

High Power Test Results

- 12 loads were ordered and 5 were high power tested.
- The loads were tested to 5 MW peak power at 1.25 ms pulse width and 60 Hz repetition rate.
- A four hour heat run was performed.
- A design iteration was done on the o-ring seals. The o-ring was replaced with a low loss material.

SureBeam 5 MW Loads

• On one load, arcing occurred because the flange was out of the flatness specification which lead to a bad electrical contact at the joint.



Damage at the O-ring Seals due to a Bad Electrical Contact

Lessons Learned and Conclusions

• During the circulator testing a deformed bellows was causing a high VSWR in the waveguide between the klystron and the circulator.

• Arcing was reduced in the waveguide run by using WR1150 instead of WR975 and replacing miter bends with sweeps.

• The window high temperature bake out helped window testing go smoothly.

• The high power testing of the windows, circulators, loads and klystrons saved many hours of commissioning time on the accelerator.

• A cleaning procedure for the ferrites in the circulators was developed. This procedure improves high power performance of the circulators.

• Sulfur Hexafluoride gas was used in both the output waveguide of the klystron and the circulator to reduce RF breakdown.

• Design iterations were performed on both the AFT Kapton window, used on both the circulator and klystron, and the o-rings on the SureBeam load after high power testing . The design of the Kapton window has been proven successful on both the circulator and the klystron.