Technical Note on the Testing of the 350MHz Waveguide Air Personnel Safety System

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Background:

Pressurization of the 350MHz waveguide system in Bldg. 420 is used as the primary means of providing rf radiation personnel protection in the event of a breach of the waveguide system (see also technical note "Measurements of RF Power Radiated From Open WR2300 Waveguide Flanges). Blowers on the rf cavities provide cooling air to the input couplers and also slightly pressurize the waveguides to ≈ 3-4"H_2O (≈ .1-.15 psi.). A basic diagram of the cavities, blowers and waveguide system is shown in Figure 1. The pressure is monitored and interlocked by eight waveguide photohelic pressure gauges, one or more of which is capable of detecting a waveguide flange gap of .185", in all available waveguide switching modes. A trip of any waveguide photohelic will shutdown all five 350MHz klystron stations. Orphan photohelics are installed at RF1 and RF3 to provide protection in these areas when the stations are switched off-line. The eight waveguide photohelics and their rack locations are listed in Table 1.

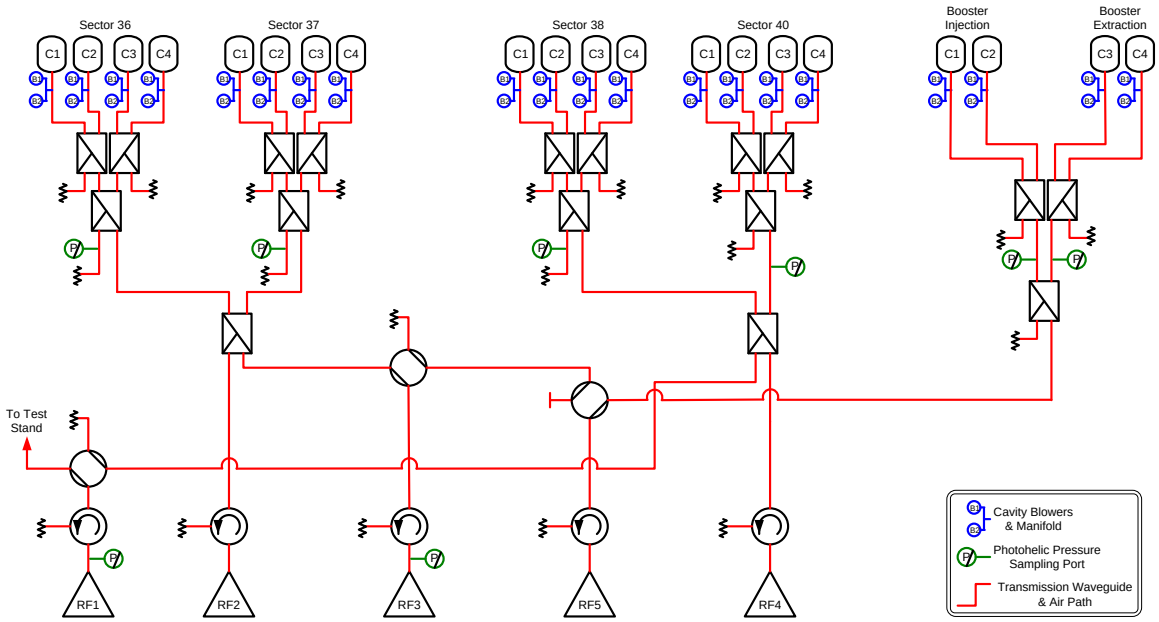

Figure 1

Table 1

Photohelic	Location
RF1/Sector 40	RF1 Rack 8
RF1 Orphan	RF1 Circulator
RF2/Sector 36	RF2 Rack 8
RF3/Sector 37	RF3 Rack 8
RF3 Orphan	RF3 Circulator
RF4/ Sector 38	RF4 Rack 8
RF5/Booster Injection	RF5 Rack 9
RF5 Booster Extraction	RF5 Rack 13

Each rf cavity has two blowers, one being redundant. Ideally, the system would be able to detect a .185" gap AND survive the loss of one redundant blower, but not the loss of two blowers in the same sector. While it is true that the system can ALWAYS detect a gap of .185", it cannot always detect the loss of two cavity blowers. This is due to the small pressure difference between the loss of one and two blowers, and the pressure interaction of the other sectors through the waveguides. In addition, the pressure changes slightly from one switching mode to the next. Figure 2 shows a chart of the data collected in May of 2005 for RF3/S37, in all twelve switching modes. Columns represent the low, high and average pressures for normal (flange closed), the loss of one blower, and a .185" gap. Lines represent the pressure with the loss of two blowers and the chosen set point.

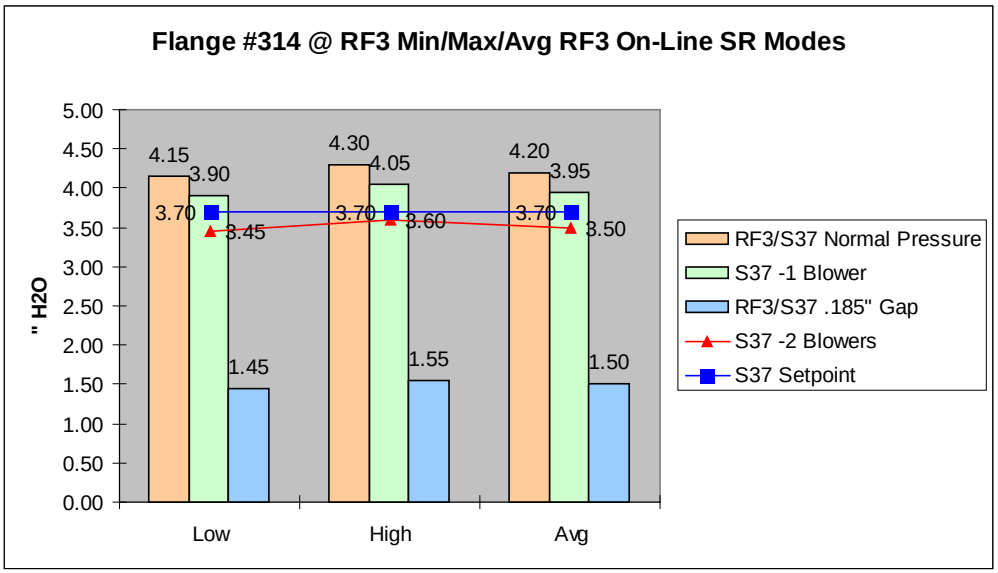

Figure 2

System Testing and Set Point Selection:

Prior to performing this work, all persons involved must LOTO the five 350MHz rf stations. Those involved in tunnel work must also LOTO the Booster tunnel and Storage Ring Zone F.

Testing and data collection should proceed using the following steps.

1) Remove all waveguide flange bolts, with the exception of the four corner bolts, from a chosen flange at each rf station. Suggested flanges are listed in table 2. These flanges were chosen for the testing performed in May 2005 for the following reasons:

a) The location is near the klystron, far from the pressure source, and prior to the splitting of rf power by the hybrids (common section of waveguide to all cavities driven by that klystron).
b) The close proximity to a flex section.
c) The location can safely be reached with the use of ladders.

Table 2

RF Station	Flange #
RF1	111
RF2	212
RF3	314
RF4	412
RF5	553

2) With **ALL** blowers turned off, check the zero of the photohelic gauge needles and adjust if necessary. Adjustments can be made by turning the zero adjustment screw directly below the gauge, as required to set the needle to zero (Figure 2).

3) Turn all blowers on and record the "normal" pressure in all sectors for the current waveguide switching mode.

4) Turn the S36 blowers off, remove the AC power cord from one blower in sector 36, turn the blowers on and record the pressure drop at the waveguide photohelics.

5) Turn the S36 blowers off, remove a second AC power cord from a blower in sector 36, turn the blowers on and record the pressure drops.

6) Turn the blowers off and reconnect the power cords. Repeat this process for the remaining sectors.

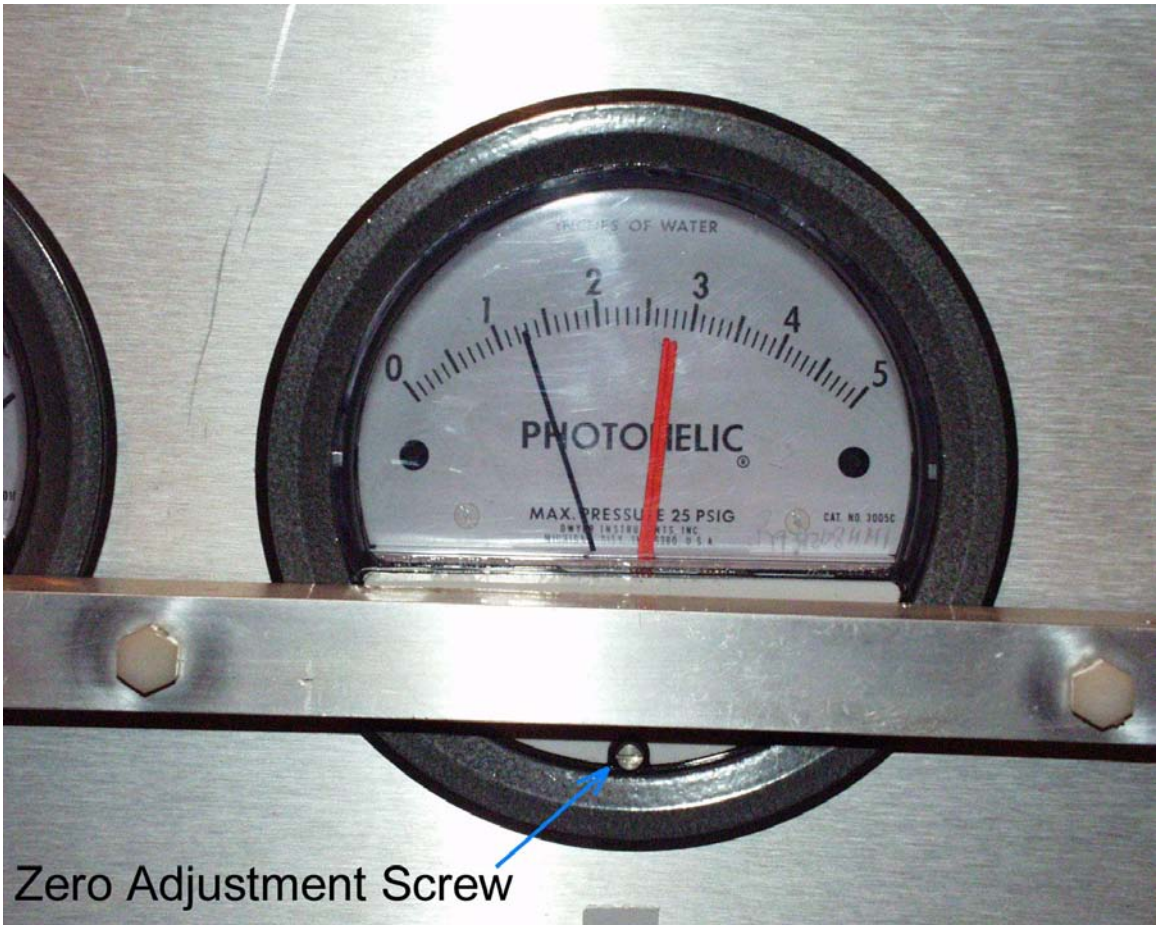

Figure 2

7) Loosen the four corner bolts at a selected waveguide flange and insert the .185” spacers (Figure 3), near the corners. Slightly tighten the flange bolts to obtain a uniform .185” gap (Figures 4 & 5).

8) Record the resulting pressure drop on the waveguide photohelics from the .185” gap. Test data sheet is provided at the end of this document.

9) Remove the spacers and secure the flange with the four corner bolts.

10) Repeat steps 7-9 for one selected flange at each rf station, in the current waveguide switching mode.

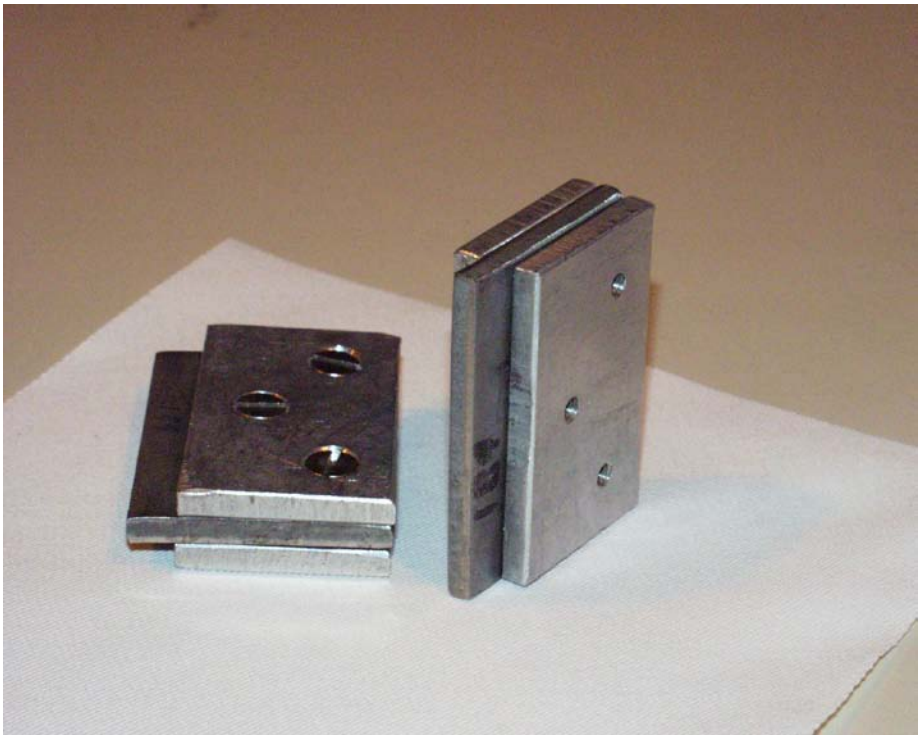

Figure 3

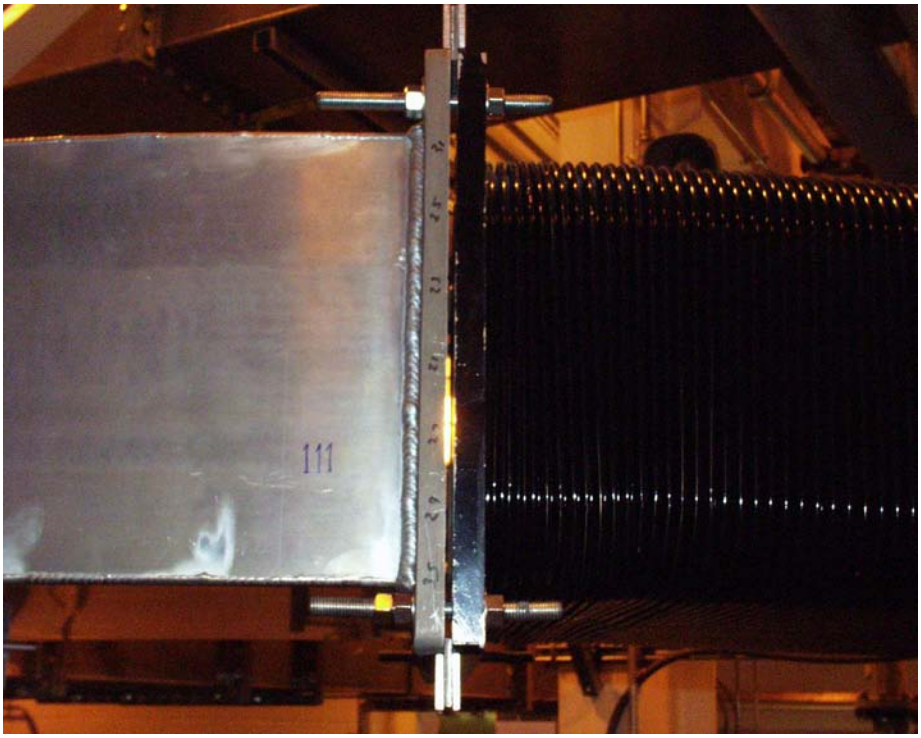

Figure 4

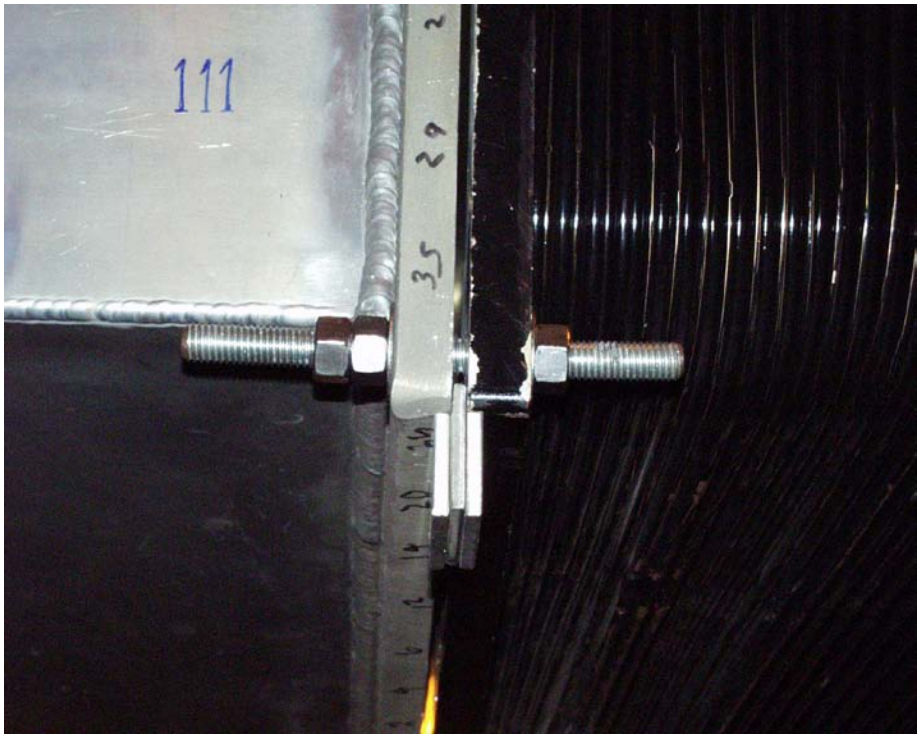

Figure 5

11) Perform a waveguide switch to an untested mode, record the “normal” (flange closed), pressure for that mode and repeat steps 7-11.

12) After the selected flanges at each rf station have been opened, and the pressure drops recorded in all waveguide switching modes, analyze the data and choose an operating set point that meets the following criteria (see Figure 2 for an example):

a) Pressure drop from a .185” gap is **BELOW** the set point in **ALL** waveguide switching modes.

b) Pressure drop from the loss of one blower in a sector **IS NOT** below the set point in all waveguide switching modes.

c) Pressure drop from the loss of two blowers in a sector **IS** below the set point (*may not be possible in all waveguide switching modes).

13) Reinstall all flange bolts.

System Validation:

1) Using the waveguide photohelic test valve (Figure 6), located above the photohelic panel, test each sector and verify that a trip is indicated at RF6 and at each station's rf interlock chassis. Validation sign-off sheet is provided at the end of this document.

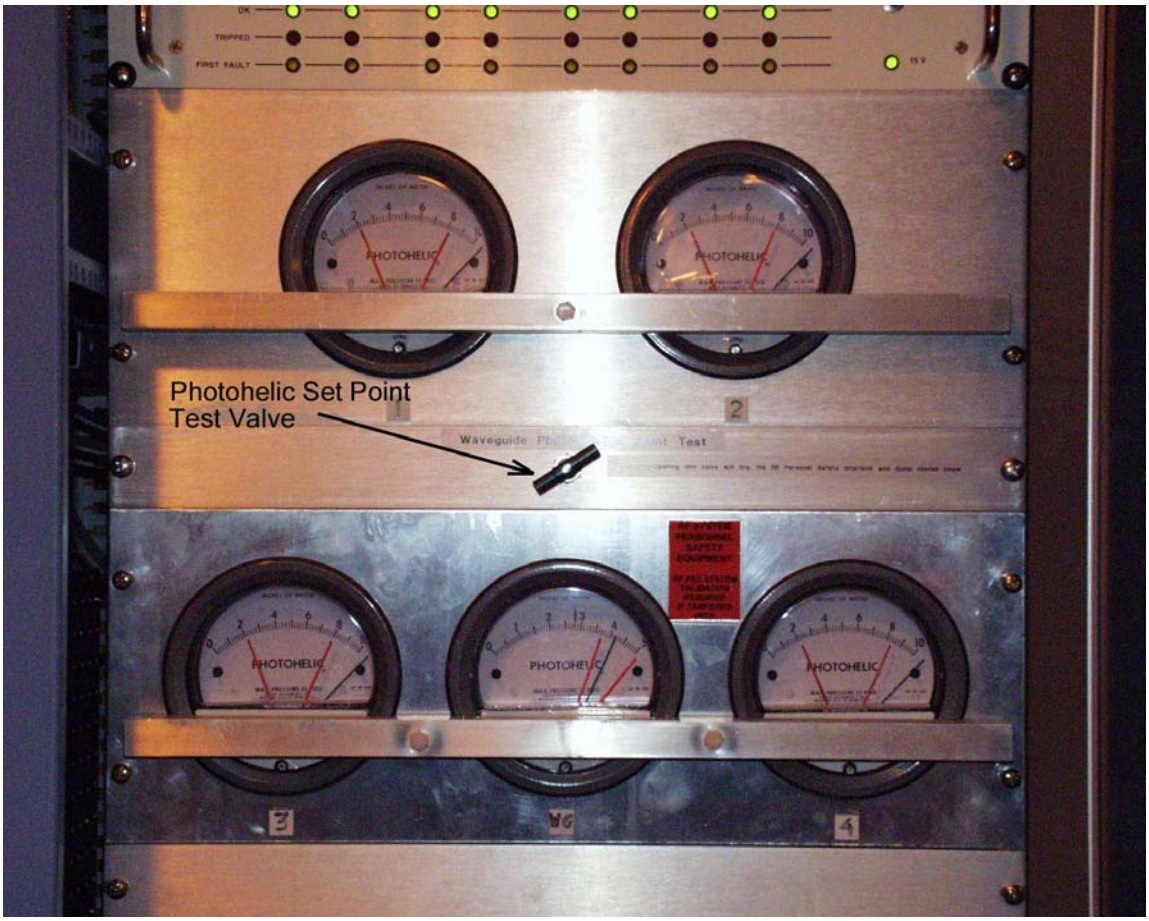

Figure 6

2) After all testing has been completed, torque and check each flange bolt to 35 ft/lbs. Sniff the flanges with a hand-held NARDA unit with a detectable amount of rf power in the waveguide. Log this validation/verification in the on-line waveguide flange logbook.

350MHz RF Systems
Waveguide Photohelic Calibration/Test Data

Date: _____ **Testing Performed By:** _____

Waveguide Switching Mode 1 Parallel: RF1/RF4 - RF2/RF3 - RF5 Booster									
		S36	RF3 Orphan	S37	S38	RF1 Orphan	S40	B-Inj	B-Ext
WG Air Pressure		WG Pressure Flanges Closed							
		1 Blower Down							
		2 Blowers Down							
	Required Gap .2" H20 < 1 Blower Down Value	Open Flange #111 @ RF1							
		Open Flange #212 @ RF2							
		Open Flange #314 @ RF3							
		Open Flange #412 @ RF4							
		Open Flange #553 @ RF5							
		WG Photohelic Set Point							

Date: _____ **Testing Performed By:** _____

Waveguide Switching Mode 2 Parallel: RF2/RF3 - RF4 - RF5 Booster									
		S36	RF3 Orphan	S37	S38	RF1 Orphan	S40	B-Inj	B-Ext
WG Air Pressure		WG Pressure Flanges Closed							
		1 Blower Down							
		2 Blowers Down							
	Required Gap .2" H20 < 1 Blower Down Value	Open Flange #111 @ RF1							
		Open Flange #212 @ RF2							
		Open Flange #314 @ RF3							
		Open Flange #412 @ RF4							
		Open Flange #553 @ RF5							
		WG Photohelic Set Point							

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Waveguide Photohelic Calibration/Test Data

Date: _____ **Testing Performed By:** _____

Waveguide Switching Mode 3 Parallel: RF1/RF4 - RF3 - RF5 Booster									
			S36	RF3 Orphan	S37	S38	RF1 Orphan	S40	B-Inj	B-Ext
WG Air Pressure		WG Pressure Flanges Closed								
		1 Blower Down								
		2 Blowers Down								
	Required Gap .2" H20 < 1 Blower Down Value	Open Flange #111 @ RF1								
		Open Flange #212 @ RF2								
		Open Flange #314 @ RF3								
		Open Flange #412 @ RF4								
		Open Flange #553 @ RF5								
		WG Photohelic Set Point								

Date: _____ **Testing Performed By:** _____

Waveguide Switching Mode 4 Parallel: RF1/RF4 - RF2 - RF5 Booster									
			S36	RF3 Orphan	S37	S38	RF1 Orphan	S40	B-Inj	B-Ext
WG Air Pressure		WG Pressure Flanges Closed								
		1 Blower Down								
		2 Blowers Down								
	Required Gap .2" H20 < 1 Blower Down Value	Open Flange #111 @ RF1								
		Open Flange #212 @ RF2								
		Open Flange #314 @ RF3								
		Open Flange #412 @ RF4								
		Open Flange #553 @ RF5								
		WG Photohelic Set Point								

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Waveguide Photohelic Calibration/Test Data

Date: _____ **Testing Performed By:** _____

Waveguide Switching Mode 5 Parallel: RF1 - RF2/RF3 - RF5 Booster									
		S36	RF3 Orphan	S37	S38	RF1 Orphan	S40	B-Inj	B-Ext
WG Air Pressure		WG Pressure Flanges Closed							
		1 Blower Down							
		2 Blowers Down							
	Required Gap .2" H20 < 1 Blower Down Value	Open Flange #111 @ RF1							
		Open Flange #212 @ RF2							
		Open Flange #314 @ RF3							
		Open Flange #412 @ RF4							
		Open Flange #553 @ RF5							
		WG Photohelic Set Point							

Date: _____ **Testing Performed By:** _____

Waveguide Switching Mode 6 Parallel: RF1/RF4 - RF2 - RF3 Booster									
		S36	RF3 Orphan	S37	S38	RF1 Orphan	S40	B-Inj	B-Ext
WG Air Pressure		WG Pressure Flanges Closed							
		1 Blower Down							
		2 Blowers Down							
	Required Gap .2" H20 < 1 Blower Down Value	Open Flange #111 @ RF1							
		Open Flange #212 @ RF2							
		Open Flange #314 @ RF3							
		Open Flange #412 @ RF4							
		Open Flange #553 @ RF5							
		WG Photohelic Set Point							

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Waveguide Photohelic Calibration/Test Data

Date: _____ **Testing Performed By:** _____

Waveguide Switching Mode 7 Single-Ended: RF2 - RF4 - RF3 Booster									
		S36	RF3 Orphan	S37	S38	RF1 Orphan	S40	B-Inj	B-Ext
WG Air Pressure	WG Pressure Flanges Closed								
	1 Blower Down								
	2 Blowers Down								
Required Gap .2" H20 < 1 Blower Down Value	Open Flange #111 @ RF1								
	Open Flange #212 @ RF2								
	Open Flange #314 @ RF3								
	Open Flange #412 @ RF4								
	Open Flange #553 @ RF5								
	WG Photohelic Set Point								

Date: _____ **Testing Performed By:** _____

Waveguide Switching Mode 8 Single-Ended: RF1 - RF2 - RF3 Booster									
		S36	RF3 Orphan	S37	S38	RF1 Orphan	S40	B-Inj	B-Ext
WG Air Pressure	WG Pressure Flanges Closed								
	1 Blower Down								
	2 Blowers Down								
Required Gap .2" H20 < 1 Blower Down Value	Open Flange #111 @ RF1								
	Open Flange #212 @ RF2								
	Open Flange #314 @ RF3								
	Open Flange #412 @ RF4								
	Open Flange #553 @ RF5								
	WG Photohelic Set Point								

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Waveguide Photohelic Calibration/Test Data

Date: _____ **Testing Performed By:** _____

Waveguide Switching Mode 9 Single-Ended: RF1 - RF2 - RF5 Booster									
		S36	RF3 Orphan	S37	S38	RF1 Orphan	S40	B-Inj	B-Ext
WG Air Pressure		WG Pressure Flanges Closed							
		1 Blower Down							
		2 Blowers Down							
	Required Gap .2" H20 < 1 Blower Down Value	Open Flange #111 @ RF1							
		Open Flange #212 @ RF2							
		Open Flange #314 @ RF3							
		Open Flange #412 @ RF4							
		Open Flange #553 @ RF5							
		WG Photohelic Set Point							

Date: _____ **Testing Performed By:** _____

Waveguide Switching Mode 10 Single-Ended: RF3 - RF4 - RF5 Booster									
		S36	RF3 Orphan	S37	S38	RF1 Orphan	S40	B-Inj	B-Ext
WG Air Pressure		WG Pressure Flanges Closed							
		1 Blower Down							
		2 Blowers Down							
	Required Gap .2" H20 < 1 Blower Down Value	Open Flange #111 @ RF1							
		Open Flange #212 @ RF2							
		Open Flange #314 @ RF3							
		Open Flange #412 @ RF4							
		Open Flange #553 @ RF5							
		WG Photohelic Set Point							

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Waveguide Photohelic Calibration/Test Data

Date: _____ **Testing Performed By:** _____

Waveguide Switching Mode 11 Single-Ended: RF2 - RF4 - RF5 Booster									
		S36	RF3 Orphan	S37	S38	RF1 Orphan	S40	B-Inj	B-Ext
WG Air Pressure		WG Pressure Flanges Closed							
		1 Blower Down							
		2 Blowers Down							
	Required Gap .2" H20 < 1 Blower Down Value	Open Flange #111 @ RF1							
		Open Flange #212 @ RF2							
		Open Flange #314 @ RF3							
		Open Flange #412 @ RF4							
		Open Flange #553 @ RF5							
		WG Photohelic Set Point							

Date: _____ **Testing Performed By:** _____

Waveguide Switching Mode 12 Single-Ended: RF1 - RF3 - RF5 Booster									
		S36	RF3 Orphan	S37	S38	RF1 Orphan	S40	B-Inj	B-Ext
WG Air Pressure		WG Pressure Flanges Closed							
		1 Blower Down							
		2 Blowers Down							
	Required Gap .2" H20 < 1 Blower Down Value	Open Flange #111 @ RF1							
		Open Flange #212 @ RF2							
		Open Flange #314 @ RF3							
		Open Flange #412 @ RF4							
		Open Flange #553 @ RF5							
		WG Photohelic Set Point							

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350MHz RF Systems
Waveguide Photohelic Calibration/Test Data

Waveguide Photohelic Set Point Changes & Validation/Verification		
Sector 36	Set Point Changed To: _____	To Match a Gap Of: _____
	Tested By: _____	Date: _____
	Validated By: _____	Date: _____
	Verified By: _____	Date: _____
Sector 37	Set Point Changed To: _____	To Match a Gap Of: _____
	Tested By: _____	Date: _____
	Validated By: _____	Date: _____
	Verified By: _____	Date: _____
Sector 38	Set Point Changed To: _____	To Match a Gap Of: _____
	Tested By: _____	Date: _____
	Validated By: _____	Date: _____
	Verified By: _____	Date: _____

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Waveguide Photohelic Calibration/Test Data

Waveguide Photohelic Set Point Changes & Validation/Verification		
Sector 40	Set Point Changed To: _____	To Match a Gap Of: _____
	Tested By: _____	Date: _____
	Validated By: _____	Date: _____
	Verified By: _____	Date: _____
Booster Injection	Set Point Changed To: _____	To Match a Gap Of: _____
	Tested By: _____	Date: _____
	Validated By: _____	Date: _____
	Verified By: _____	Date: _____
Booster Extraction	Set Point Changed To: _____	To Match a Gap Of: _____
	Tested By: _____	Date: _____
	Validated By: _____	Date: _____
	Verified By: _____	Date: _____

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Waveguide Photohelic Calibration/Test Data

Waveguide Photohelic Set Point Changes & Validation/Verification		
RF1 Orphan	Set Point Changed To: _____	To Match a Gap Of: _____
	Tested By: _____	Date: _____
	Validated By: _____	Date: _____
	Verified By: _____	Date: _____
RF3 Orphan	Set Point Changed To: _____	To Match a Gap Of: _____
	Tested By: _____	Date: _____
	Validated By: _____	Date: _____
	Verified By: _____	Date: _____

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Waveguide Photohelic Test Validation Sheet

Date: _____

Sector 36 Tested By: _____

RF6 Trip? ☐ Witnessed By: _____

RF Interlock Chassis Trip? ☐ Witnessed By: _____

****

Sector 37 Tested By: _____

RF6 Trip? ☐ Witnessed By: _____

RF Interlock Chassis Trip? ☐ Witnessed By: _____

****

Sector 38 Tested By: _____

RF6 Trip? ☐ Witnessed By: _____

RF Interlock Chassis Trip? ☐ Witnessed By: _____

****

Sector 40 Tested By: _____

RF6 Trip? ☐ Witnessed By: _____

RF Interlock Chassis Trip? ☐ Witnessed By: _____

****

RF1 Orphan Tested By: _____

RF6 Trip? ☐ Witnessed By: _____

RF Interlock Chassis Trip? ☐ Witnessed By: _____

****

RF3 Orphan Tested By: _____

RF6 Trip? ☐ Witnessed By: _____

RF Interlock Chassis Trip? ☐ Witnessed By: _____

****

Booster Injection Tested By: _____

RF6 Trip? ☐ Witnessed By: _____

RF Interlock Chassis Trip? ☐ Witnessed By: _____

****

Booster Extraction Tested By: _____

RF6 Trip? ☐ Witnessed By: _____

RF Interlock Chassis Trip? ☐ Witnessed By: _____