DEPARTMENT OF THE AIR FORCE
AIR FORCE INSTITUTE FOR OPERATIONAL HEALTH (AFMC)
BROOKS CITY-BASE TEXAS

12 Apr 06

MEMORANDUM FOR 96TH AMDS/SGPB
504 W. CHOCTAWHATCHEE AVE
EGLIN AFB FL 32542

FROM: AFIOH/SDR
2350 Gillingham Drive
Brooks City-Base TX 78235-5103

SUBJECT: Consult Letter, IOH-SD-BR-CL-2006-0038, Radio Frequency Radiation Hazard Survey for the Solidyne Type F 10-55 RF Sealer, Eglin AFB, FL

1. Introduction: The 96th AMDS/SGPB, Eglin AFB, FL tasked the Air Force Institute for Operational Health, Radiation Surveillance Division, Health Physics Consulting Branch (AFIOH/SDRH) to measure the radio frequency (RF) power densities generated by the Solidyne Type F 10-55 RF Heat Sealer. The American National Standards Institute (ANSI), in ANSI C95.1-1991, *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*, published permissible exposure limits (PEL) as a function of frequency as recommended by the Institute of Electrical and Electronic Engineers (IEEE). Air Force Occupational Safety and Health Standard (AFOSH) 48-9, *Radio Frequency Radiation (RFR) Safety Program*, incorporates ANSI C95.1-1991 for all sources of RFR owned or operated by the US Air Force (USAF), or under USAF control. From 2-6 May 05, Capt Néstor A. Ruiz and 1Lt Piper Williams conducted on-site surveys and compared the measurements with the most conservative controlled and uncontrolled PEL for the Heat Sealer operating frequency. No measurements exceeded the PEL.

2. Background:

a. The Solidyne Type F 10-55 RF Heat Sealer is used to manufacture radar dome covers. The unit had been disassembled and placed into storage while a new building was built. After the building was finished, the unit was reassembled and it was necessary to accomplish a new initial survey to determine if a RFR hazard existed to personnel. Table 1 lists the system parameters used while performing the measurements.

Table 1. System Parameters for the Solidyne Type F 10-55 Heat Sealer

Frequency [MHz]	27.12
Peak Power [kW]	10
Max Current [amps]	2
Duty Factor	0.266

b. A controlled environment is defined as those locations where a RFR exposure in excess of the uncontrolled PEL may be incurred by persons that are aware that a RFR hazard exists. Uncontrolled environments are locations where the individuals being potentially exposed have no knowledge or control of their exposure. The whole-body, controlled and uncontrolled, electric-field (E-Field) PEL values for the heat sealer, operating at 27.12 MHz, are 1.22 and 0.24 milliwatts per centimeter square (mW/cm^2), respectively. The whole-body, controlled and uncontrolled, magnetic-field (H-Field) PEL value is 13.60 mW/cm^2. The averaging time is six minutes for controlled exposures and 30 minutes for uncontrolled.

c. In general, for frequencies below 300 MHz, both the E-Field and H-Field should be measured. However, compliance with the PELs can be determined by a detailed analysis of measurements of one field. For frequencies below 30 MHz induced body currents and the corresponding risk of RF shocks or burns becomes a concern. The limit for induced and contact RF currents, for a frequency of 27.12 MHz, is 200 milli-amps (mA) through both feet and 100 mA through each foot.

3. Methodology:

a. During heat sealer operations the crew consists of four workers in the locations described in Figure 1, Attachment 2. Operators 1 and 2 are responsible for operating the RF heat sealer. Operators 3 and 4 are responsible for making sure that the material is properly aligned, stretched, and for rolling and advancing it.

b. Measurements were performed along the vertical plane in front of the operator to provide an average for the whole-body. RF radiation is only emitter during eight seconds every time the sealer die is energized. As described by the operators, they perform a maximum of two seals in a minute. Given that the die is not energized during 100% of the averaging time (six minutes), the PEL may be adjusted to account for the amount of time the die is actually energized or the duty factor. The whole-body, controlled E-Field PEL, adjusted for the duty factor is then,

$$PEL_{adj} = \frac{PEL_{6-\min}}{\frac{(Seals/\min)(\sec/seal)(6\min)}{360\sec}}$$

$$PEL_{adj} = \frac{1.22 mW/cm^2}{\frac{(2seals/\min)(8\sec/seal)(6\min)}{360\sec}}$$

$$PEL_{adj} = 4.58 mW/cm^2$$

c. Table 2 summarizes the whole-body adjusted PELs calculated as above.

Table 2. Whole-Body Permissible Exposure Limits Adjusted for Duty Factor

Field-Area	PEL [mW/cm^2]	Averaging Time [min]	Adjusted PEL [mW/cm^2]
E-Field-Controlled	1.22	6	4.58
H-Field-Controlled	13.6	6	51.1
E-Field-Uncontrolled	0.24	30	0.90
H-Field-Uncontrolled	13.6	30	51.1

d. Induced current measurements for Operators 1 and 2 were performed both in standing and sitting position with both feet in contact with the measuring instrumentation. Their locations would provide the worst case because of the close proximity to the sealer die. A list of personnel contacted and instrumentation used is included in Attachment 1.

4. Results:

a. The operators are not exposed to power densities in excess of the PEL adjusted for the duty factor. Table 3 provides a summary of the measurements. Refer to Attachments 2 and 3 for measurement locations. Detailed measurements results can be found in Attachments 4-7.

Table 3. Measurements summary

Location	Max Whole-Body Averaged Power Density-Electric Field [mW/cm^2]*	Max Whole-Body Averaged Power Density-Magnetic Field [mW/cm^2]**	Max Induced Current [mA]***
Operator 1	2.72	3.93	74.1
Operator 2	1.81	1.96	88.3
Operator 3	3.30	0.15	Not measured
Operator 4	0.2	Not measured	Not measured
Across Table	0.72	Not measured	Not measured

* Whole-body, controlled, E-Field PEL (adjusted for duty factor) is 4.58 mW/cm^2
** Whole-body, controlled, H-Field PEL (adjusted for duty factor) is 51.1 mW/cm^2
*** Limit is 200 mA

b. Measurements of induced currents for Operator 1 and 2 were at least 50% below the limit and are considered the worst case scenario due to their proximity to the die.

c. Given the distance from Operator 3 to the die, and the power density measurements at the other operator's locations, the power density corresponding to the H-Field for Operator 4 is not expected to exceed the PEL.

d. RF radiation warning signs are posted at the entry points. However, if the doors are kept open the signs may not be visible. Please see Attachment 8.

e. Prior to our survey, the Bioenvironmental Engineering Flight (BEE) placed some pieces of wood between metal frames and metallic electrical conduits. As confirmed by our measurements this action greatly reduced RF re-emissions.

f. The average power density (E-Field) measurements, one foot from the RF sealer cabinet, on the left side (Operator 2), right side, and behind it were 1.79 mW/cm^2, 0.77 mW/cm^2, and 0.47 mW/cm^2, respectively. The highest readings occurred, repeatedly, at a height of 4-6 feet.

g. Operator 1's body gets closer to the die as he pushes the RF-ON button. This is due to a difference in installation design of the RF-ON button on both sides. Operator 2, however, may comfortably use the full extension of his arm, resulting in a greater distance from the die than that of Operator 1. Please see Attachment 9.

5. Recommendations:

a. Limit the RF "on-time" to eight seconds and the number of seals to 2 in any minute or any combination that would result in a duty factor of less or equal to 0.27. The goal is to maintain the power densities below the adjusted E-Field PEL of 4.57 mW/cm^2 in section 3.b.

b. To assure that RF radiation warning signs are always visible to personnel entering the work area, place RF radiation warning signs next to the door frame, at eye level, and opposite to the side that has the door hinges.

c. Change the installation design of the RF-ON button used by Operator 1 to match that of the RF-ON button used by Operator 2.

6. Acknowledgments: We would like to thank all the operators, supervisors and BEE Flight personnel for the unconditional availability and assistance during our survey. Their feedback, experience, and skills contributed to acquiring very useful measurements.

7. Please fill and return the critique form included in Attachment 10. If you have any questions please contact Capt Néstor A. Ruiz by calling DSN 240-5364 or sending an email to Nestor.Ruiz@brooks.af.mil.

//signed//

SCOTT M. NICHELSON, Lt Col, USAF, BSC, CHP, CIH
Chief, Radiation Surveillance Division

Attachments:

1. Personnel contacted
2. Measurement Locations
3. Measurement Locations-Operators
4. Power Density Measurements-Operator 1
5. Power Density Measurements-Operator 2
6. Power Density Measurements-Operator 3
7. Power Density Measurements-Operator 4
8. RF Warning Signs and RF Sealer
9. Operator’s 1 &2 RF-ON Push Button
10. Critique Form

Attachment 1
Personnel Contacted

1. Lt Col Robert Tetla, Eglin BEE shop, DSN: 875-1491
2. Mr. Steve Curry, Eglin BEE shop, DSN: 875-8294, Cell: 850-368-0815

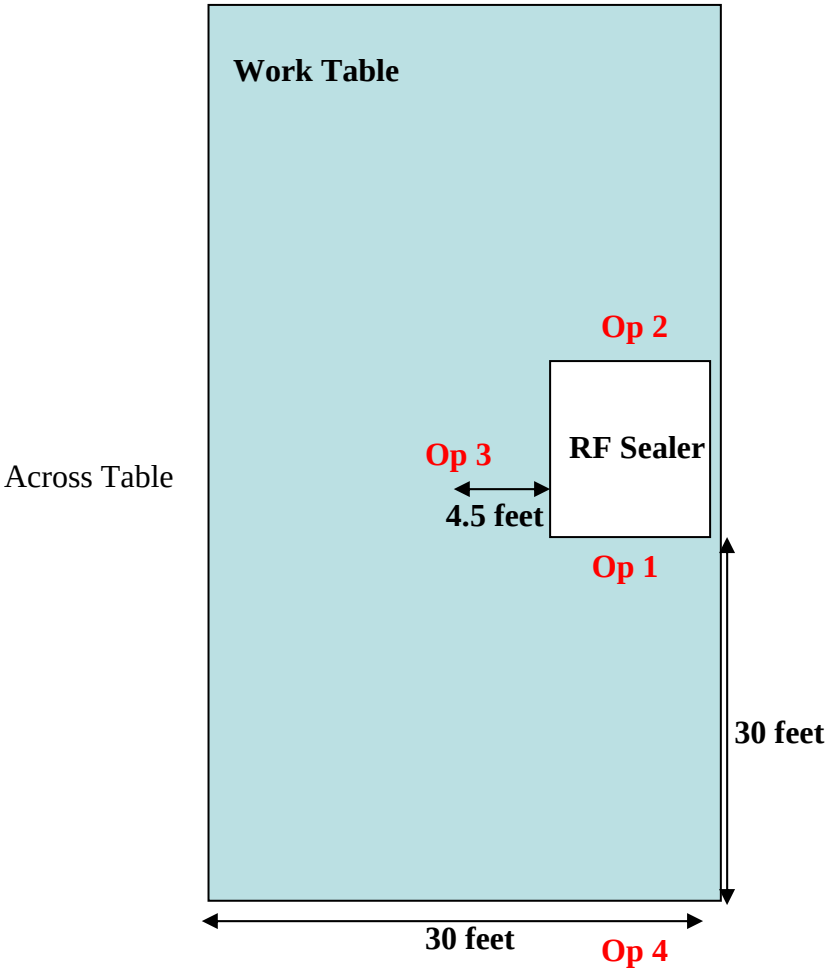
Equipment

1. Meter: Narda meter model 8718, s/n S021071
   Cal date: 25 Jan 04, Cal due: 14 Jan 06

2. Probes: Narda 8762, s/n 07009
   Cal date: 25 Jan 04, Cal due: 14 Jan 06
   Narda 8733, s/n 04016
   Cal date: 25 Jan 04, Cal due: 14 Jan06

3. Holaday Hi-3701 Induced Current meter, s/n 61276
   Cal date: 01 Jul 04, Cal due: 01 Oct 05

Attachment 2
Measurement Locations



Attachment 3
Measurement Locations-Operators

Attachment 4
Power Density Measurements-Operator 1
Units of mW/cm^2

	E-Field				H-Field			
Location	Set #1	Corrected	Set #2	Corrected	Set #1	Corrected	Set #2	Corrected
Head	4.8	6.25	3.8	4.95	7.1	5.90	8.5	7.06
Neck	1.6	2.08	2.9	3.77	2.8	2.32	3.1	2.57
Chest	1.0	1.30	0.74	0.96	4.0	3.32	11	9.13
Waist	3.4	4.43	2.8	3.64	2.5	2.08	5.8	4.82
Groin	4.2	5.47	3.2	4.16	1.5	1.25	5.2	4.32
Thigh	0.84	1.09	0.68	0.89	1.6	1.33	2.1	1.74
Calf	0.48	0.62	0.77	1.00	0.67	0.56	1.2	1.00
Ankle	0.38	0.49	0.31	0.40	0.8	0.66	0.93	0.77
Average	**2.09**	**2.72**	**1.9**	**2.47**	**2.62**	**2.18**	**4.73**	**3.93**

E-field Probe correction factor = 1.3015
H-Field Probe correction factor = 0.8303
Whole-body (E-Field) controlled PEL (adjusted for duty factor) is 4.575 mW/cm^2
Whole-body (H-Field) controlled PEL (adjusted for duty factor) is 51.127 mW/cm^2
Whole-body (E-Field) uncontrolled PEL (adjusted for duty factor) is 0.902 mW/cm^2
Whole-body (H-Field) uncontrolled PEL (adjusted for duty factor) is 51.127 mW/cm^2

Induced Current Measurements-Operator 1
Units of mA

	Standing				Sitting				Without Mat	
	Set #1	Corrected	Set #2	Corrected	Set #1	Corrected	Set #2	Corrected	Set #1	Corrected
Reading #1	60	62.38	75.1	78.08	68.2	70.90	68.7	71.42	88.8	92.32
Reading #2	71.3	74.13	62.1	64.56	66.2	68.82	69.9	72.67		
Reading #3	82.4	85.67	64.8	67.37	70	72.77	68	70.70		
Average	**71.23**	**74.06**	**67.33**	**70.00**	**68.13**	**70.83**	**68.87**	**71.60**		

Calibration Factor = 1.03964
Limit is 200 mA

Attachment 5
Power Density Measurements-Operator 2
Units of mW/cm^2

	E-Field				H-Field			
Location	Set #1	Corrected	Set #2	Corrected	Set #1	Corrected	Set #2	Corrected
Head	1.3	1.69	1.3	1.69	2.9	2.41	5.90	4.90
Neck	1.4	1.82	0.76	0.99	3.6	2.99	2.10	1.74
Chest	1.2	1.56	1.6	2.08	3.4	2.82	2.40	1.99
Waist	1.2	1.56	1.3	1.69	3.3	2.74	2.20	1.83
Groin	1.2	1.56	2.2	2.86	2	1.66	1.50	1.25
Thigh	2.1	2.73	1.2	1.56	1.8	1.49	0.91	0.76
Calf	1.3	1.69	1	1.30	1.2	1.00	0.51	0.42
Ankle	1.4	1.82	1.3	1.69	0.68	0.56	0.28	0.23
Average	**1.39**	**1.81**	**1.33**	**1.73**	**2.36**	**1.96**	**1.76**	**1.17**

E-field Probe correction factor = 1.3015
H-Field Probe correction factor = 0.8303
Whole-body (E-Field) controlled PEL (adjusted for duty factor) is 4.575 mW/cm^2
Whole-body (H-Field) controlled PEL (adjusted for duty factor) is 51.127 mW/cm^2
Whole-body (E-Field) uncontrolled PEL (adjusted for duty factor) is 0.902 mW/cm^2
Whole-body (H-Field) uncontrolled PEL (adjusted for duty factor) is 51.127 mW/cm^2

Induced Current Measurements-Operator 2
Units of mA

	Standing				Sitting			
	Set #1	Corrected	Set #2	Corrected	Set #1	Corrected	Set #2	Corrected
Reading #1	84.90	88.27	81.80	85.04	76.40	79.43	79.50	82.65
Reading #2	81.50	84.73	84.10	87.43	76.80	79.84	78.40	81.51
Reading #3	81.40	84.63	79.00	82.13	76.70	79.74	77.60	80.68
Average	**82.60**	**85.87**	**81.63**	**84.87**	**76.63**	**79.67**	**78.50**	**81.61**

Calibration Factor = 1.03964
Limit is 200 mA

Attachment 6
Power Density Measurements-Operator 3
Units of mW/cm^2

	E-Field				H-Field			
Location	Set #1	Corrected	Set #2	Corrected	Set #1	Corrected	Set #2	Corrected
Head	3.8	4.95	1.7	2.21	0.18	0.15	0.15	0.12
Neck	5.8	7.55	2.5	3.25	*		*	
Chest	1.4	1.82	0.445	0.58	*		*	
Waist	0.83	1.08	0.39	0.51	*		*	
Groin	0.83	1.08	1.4	1.82	*		*	
Thigh					*		*	
Calf					*		*	
Ankle					*		*	
Average	**2.53**	**3.30**	**1.29**	**1.68**	**0.18**	**0.15**	**0.15**	**0.12**

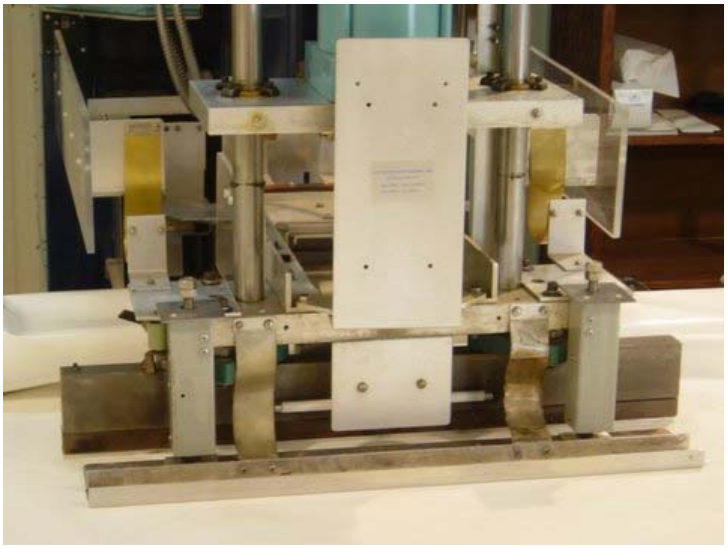
E-field Probe correction factor = 1.3015
H-Field Probe correction factor = 0.8303
Whole-body (E-Field) controlled PEL (adjusted for duty factor) is 4.575 mW/cm^2
Whole-body (H-Field) controlled PEL (adjusted for duty factor) is 51.127 mW/cm^2
Whole-body (E-Field) uncontrolled PEL (adjusted for duty factor) is 0.902 mW/cm^2
Whole-body (H-Field) uncontrolled PEL (adjusted for duty factor) is 51.127 mW/cm^2
* No more measurements performed because we noticed that the power densities due to the H-Field were far below the PEL

Attachment 7
Power Density Measurements-Operator 4
Units of mW/cm^2

	E-Field	
Location	Set #1	Corrected
Head	0.26	0.33839
Neck	0.2	0.2603
Chest	0.11	0.143165
Waist		
Groin		
Thigh		
Calf	0.19	0.25
Ankle	0.26	0.33839
Average	**0.2**	**0.2603**

E-field Probe correction factor = 1.3015
Whole-body (E-Field) controlled PEL (adjusted for duty factor) is 4.575 mW/cm^2
Whole-body (H-Field) controlled PEL (adjusted for duty factor) is 51.127 mW/cm^2
Whole-body (E-Field) uncontrolled PEL (adjusted for duty factor) is 0.902 mW/cm^2
Whole-body (H-Field) uncontrolled PEL (adjusted for duty factor) is 51.127 mW/cm^2

Attachment 8
RF Warning Signs and RF Sealer



Attachment 9
Operator's 1 &2 RF-ON Push Button

Attachment 10

POINT OF CONTACT:	**Capt Néstor A. Ruiz**	**BASE NAME:**	**Brooks City-Base**
POC PHONE:	**DSN 240-5364**	**DIVISION:**	**AFIOH/SDRH**
STINFO NUMBERS:	**IOH-SD-BR-CL-2006-0038**		

This survey is used to help us improve our service to you. Your answer will be held in confidence and will significantly impact on how we allocate resources to meet your needs. Please return this completed form promptly.

Grading Scale:

1	2	3	4	5	6
Extremely Dissatisfied	Dissatisfied	Slightly Dissatisfied	Slightly Satisfied	Satisfied	Extremely Satisfied

A	Timeliness: Did you receive your results within the published time limits?	1	2	3	4	5	6
B	Accuracy: Is the report in the proper format? Are your address and other data correct?	1	2	3	4	5	6
C	Content: Does the report answer your questions and provide the necessary data? Are our services per dollar adequate when compared to civilian sector?	1	2	3	4	5	6
D	Customer Support: Have we been courteous and helpful in meeting your special needs (priority service, reporting, format, etc.)?	1	2	3	4	5	6
E	Consult Service: Have we answered your questions and provided necessary materials or reviewed to support your mission requirements?	1	2	3	4	5	6
F	Overall Rating: How would you rate our overall service to you?	1	2	3	4	5	6

Comments / Suggestions: Are there other services that you would like provided in the future? Are there any specifics of your current service you would like to discuss? (Use additional pages if more space is required)

Please return to:

AFIOH/SDR
Attention: Lt Col Scott M. Nichelson
Chief, Radiation Surveillance Division
2350 Gillingham Drive
Brooks City-Base TX 78235-5103