Neil A. Armstrong Flight Research Center

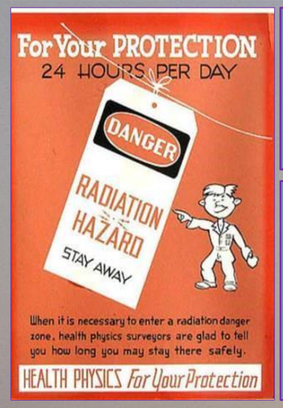
RADIATION SAFETY PROGRAM

Maria B. Stone

Student
Maria Babakhanyan Stone
San José State University

Mentor
Dr. Miriam Rodón-Vachon
Health Physics Manager

HEALTH PHYSICS



Armstrong Flight Research Center mission

"to leverage atmosphere flight expertise to advance technology and science for the benefit of NASA and the Nation."

Safety is a key requirement for mission success.

Health Physics

is the application of scientific principles to the protection of people from the hazards of radiation.

RADIATION EXPOSURE HAZARD SOURCES

X-Ray Cabinets, X-Ray instruments, any equipment with active radioisotope source

Radar Equipment in the ER-2 chase car

Lasers aboard DC-8 Missions, e.g. ASCENDS II

Scientific Research Instruments from Universities and Research Institutes on platforms for Airborne Science Missions such as ATom, KORUS, and Ice-Bridge.
Photo: DC-8 aircraft with different probes sticking out of windows.

Radio-frequency and Microwave radiation from transmitting antennae and other telemetry and communication systems.

HUMAN HEALTH RISK REDUCTION: EXAMPLE

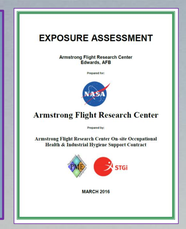
Identification

RF radiation can cause known biological damage by tissue heating. The effects might be: whole-body heating, cataract formation, testicular damage. For example, cataracts (opacity in the lens) can be produced with a single exposure at a threshold power density exceeding 100mW/cm².

AFRC follows the IEEE Std C95.7-2014 to develop an RF safety program

1. to facilitate safe operation of the RF energy-producing equipment, systems, and devices
2. to make sure that both workers and the public are not exposed to hazardous levels of radiation

The first phase in the Identification step is the *Exposure Assessment Report* for each branch.

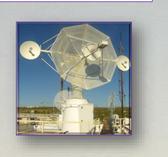

EXPOSURE ASSESSMENT
Armstrong Flight Research Center
Edwards, AFB
Armstrong Flight Research Center
Armstrong Flight Research Center On-site Occupational Health & Industrial Hygiene Support Contract
MARCH 2016

Inventory

We collaborate with the users of RF equipment to create the first AFRC inventory of RF devices.

Table 1. AFRC Radiofrequency (RF) Inventory

RF instrument	Frequency (Hertz)	Average Power (Watts)	Gain (dB)	Exposure Category
Antenna Example	3,400,000	2,000	2	To be determined in the next step



Evaluation and Hazard Analysis

Then we use the IEEE Standard maximum exposure limits (MEL) to categorize each RF instrument and to assess the Hazard Distance. Many factors must be considered, e.g. per IEEE Std C95.1

- The *Maximum Permissible Exposure* levels are different for the general public and for the workers.
- Exposure levels vary depending on the frequency of the instrument.

$$R_{MEL} = \sqrt{\frac{Power \times Gabs}{MEL \times 4\pi}}$$

$$R = Hazard\ Distance$$

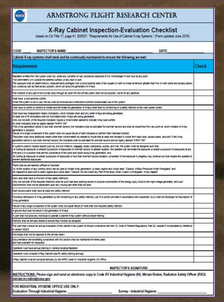
Table 2. RF Exposure Categories

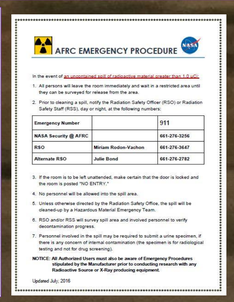
1	Public Exposure limit is not exceeded.
2	Public Exposure limit is exceeded. The Occupational Exposure limit is not exceeded.
3	Public Exposure limit is exceeded. There is a potential to exceed the Occupational Exposure limit.
4	Exposure will exceed ten times the Occupational Exposure limit.

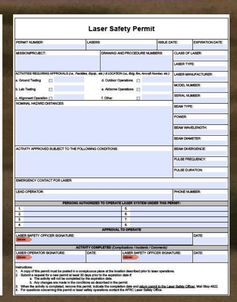
Recommendations and Implementations of Controls

Based on the RF Exposure Category, the recommended controls can be

- Follow up calculations with Surveys and Direct Measurements
- Posted Signs and site guidelines
- RF Awareness Training
- Advanced RF Training for workers in radio-frequency environments
- Permits
- Restricting access to the areas with RF equipment, e.g. fences
- Developing safe work practices by Standard Operating Procedures
- Lockout/ tag-out procedures
- Control of source power (e.g. turning off the power before access)
- Personal and/or area monitors
- Personal Protective Equipment


ARMSTRONG FLIGHT RESEARCH CENTER
X-Ray Cabinet Inspection-Evaluation Checklist


AFRC EMERGENCY PROCEDURE


Laser Safety Permit

PROGRAM RESULTS

- Developed and updated radiation equipment inventories, to include the first RF inventory for the Center
- Evaluated and analyzed health hazards
- Recommended and implemented controls, such as Safety Training and Awareness campaigns
- Developed Training materials and maintained Training records
- Developed Inspection Checklists, Inventory spreadsheets, Emergency Procedures Posters, Safety Signs
- Created Radiation Safety Newsletter

PROGRAM CHALLENGES

- Acquiring data for inventories of RF equipment is challenging
- Diversity of RF equipment
- The regulation standards are not always user-friendly
- Requires great collaboration
- RF equipment may affect medical devices and implants
- Need to consider electro-explosive devices if present

NEXT STEPS

- *Ensure* compliance with Safety Regulations
- Program Self-Assessment
- Equipment Self-Inspections
- Program Audit
- Safer Environment
- Compliance with Safety Regulations

ACKNOWLEDGEMENTS

Industrial Hygiene branch, Dr. Gregg Bendrick (Chief Medical Officer), Charles Kreager, Greg Strombo, Darryl Burkes, Airborne Science Program personnel, Mr. Eddie Zavala (SOFIA Program Manager), Mr. David McCallister (Deputy Program Manager), Chuck Irving (Associate Director, Science Mission Directorate), and personnel from NASA AFRC, AMES, and JPL

REFERENCES

OSHA, ANSI 136.1, IEEE 95.1, CA Title 17 Safety Standards, NPR 1800.1D, DPL 1800.1, DPC. Images from NASA public archives and personal photos by NASA AFRC personnel