AC NO: 20-68

DATE: 3/11/70

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: RECOMMENDED RADIATION SAFETY PRECAUTIONS FOR AIRBORNE WEATHER RADAR

1. PURPOSE. This circular sets forth recommended radiation safety precautions for ground operation of airborne weather radar. These general recommendations are, in some instances, based on past experience, but are not intended to be used in lieu of specific analysis by qualified personnel in each situation.

2. REFERENCES. Barnes and Taylor: "Radiation Hazards and Protection," George Newnes Limited, London, 1963 page 211, Environmental Health Series: "Standards and Guides for Microwaves, " U. S. Public Health Service, Health, Education and Welfare Agency, Consumer Protection Environmental Service, pages 56-57

3. BACKGROUND. Dangers from ground operation of airborne weather radar include the possibility of human body damage and ignition of combustible materials by radiated energy. Since this possibility exists it is advisable to provide recommended practices.

4. PRECAUTIONS.

   a. General.

      (1) Installed airborne weather radar should be operated on the ground only by qualified, authorized personnel.

      (2) Installed airborne radar should not be operated while the aircraft is in a hangar or other enclosure unless the radar transmitter is deactivated, or the energy is directed toward an absorption shield which dissipates or scatters the RF energy, or the antenna is pointing so as to direct the energy through an open hangar door.

   b. Body Damage.

      (1) Personnel should never stand nearby and in front of a radar

Initiated by: FS-130

antenna which is transmitting, but not scanning unless the antenna is tilted upward to clear ground personnel and nearby obstructions.

(2) When the airborne radar is operating with the antenna scanning a recommended safe distance should be specified indicating how far away personnel should remain, based on the type of radar, including parameters of average power output, pulse repetition, pulse width, wavelength, and antenna gain. A safe distance can be calculated using these variables in accordance with the equations in Appendix 1. This procedure is now accepted by many industrial organizations and is based on limiting exposure of humans to an average power density not greater than 100 watts per square meter and is recommended for this purpose. If no calculation has been made, a safe distance of 10 feet is recommended.

(3) Personnel should not be allowed at the end of an open waveguide unless the radar is turned off and will remain off. Radar should not be operated with an open waveguide unless a "dummy load" is connected to the portion which is connected to the transmitter.

(4) Personnel should not look into a waveguide, or into the open end of a coaxial connector or line connected to a radar transmitter output, unless necessary, and then only when it has been determined that the RF power is off. Severe eye damage may result from radiation.

(5) When high power radar transmitters are operated out of their protective cases, there may be X-rays emitted. Stray X-rays may emanate from the glass envelope type pulser, oscillator, clipper or rectifier tubes, as well as magnetrons. Although the likelihood of danger of X-rays with most airborne radars is small, it is recommended that the following precautions should be taken:

(a) Obtain data from the manufacturer indicating if their radar is a source of dangerous X-ray radiation and be guided by the manufacturer's recommendations.

(b) Make an engineering analysis of the possibility of X-ray emission and be guided by such findings.

c. Combustible Materials. Weather radar installed on aircraft should not be operated while that aircraft is being refueled or defueled.

acting Director,
Flight Standards Service

APPENDIX 1. RADIATION SAFETY PRECAUTIONS FOR AIRBORNE RADAR

If more precise safety limits are desired, the following procedure can be used:

1. Safe Power Density Limit. Extensive experimental research into the hazard to humans from microwave radiation has been carried on since about 1942. The accepted safe limit has varied considerably over the years but it is now accepted by the Armed Services and several industrial organizations that humans should not be exposed to microwave radiation of average power density greater than 10 mw/cm^2 (100 watts/meter^2).

2. Power Density Variation. Power density within the near field of an antenna is oscillatory in nature and thus cannot be computed as a function of distance from the antenna. However, the maximum power density that will occur in the near field may be calculated by

$$W_{max} = \frac{GP}{4\pi Ro^2} \qquad (1)$$

where Wmax = Maximum power density in watts/m^2
G = Antenna gain in db
P = Transmitted average power in watts
Pax = Ppk x PRF x Pulse Width
Ro = Distance to near field/far field intersection

Ro in feet may be computed from

$$Ro = \frac{Gc}{4\pi f} \qquad (2)$$

where G = Antenna gain
c = Speed of light in feet/sec (9.84×10^8)
f = Transmitter frequency

Power density in the far field of the antenna varies as a function of range per the inverse square law and may be expressed as follows:

$$W = \frac{GP}{4\pi r^2}$$

where r = distance from the antenna.

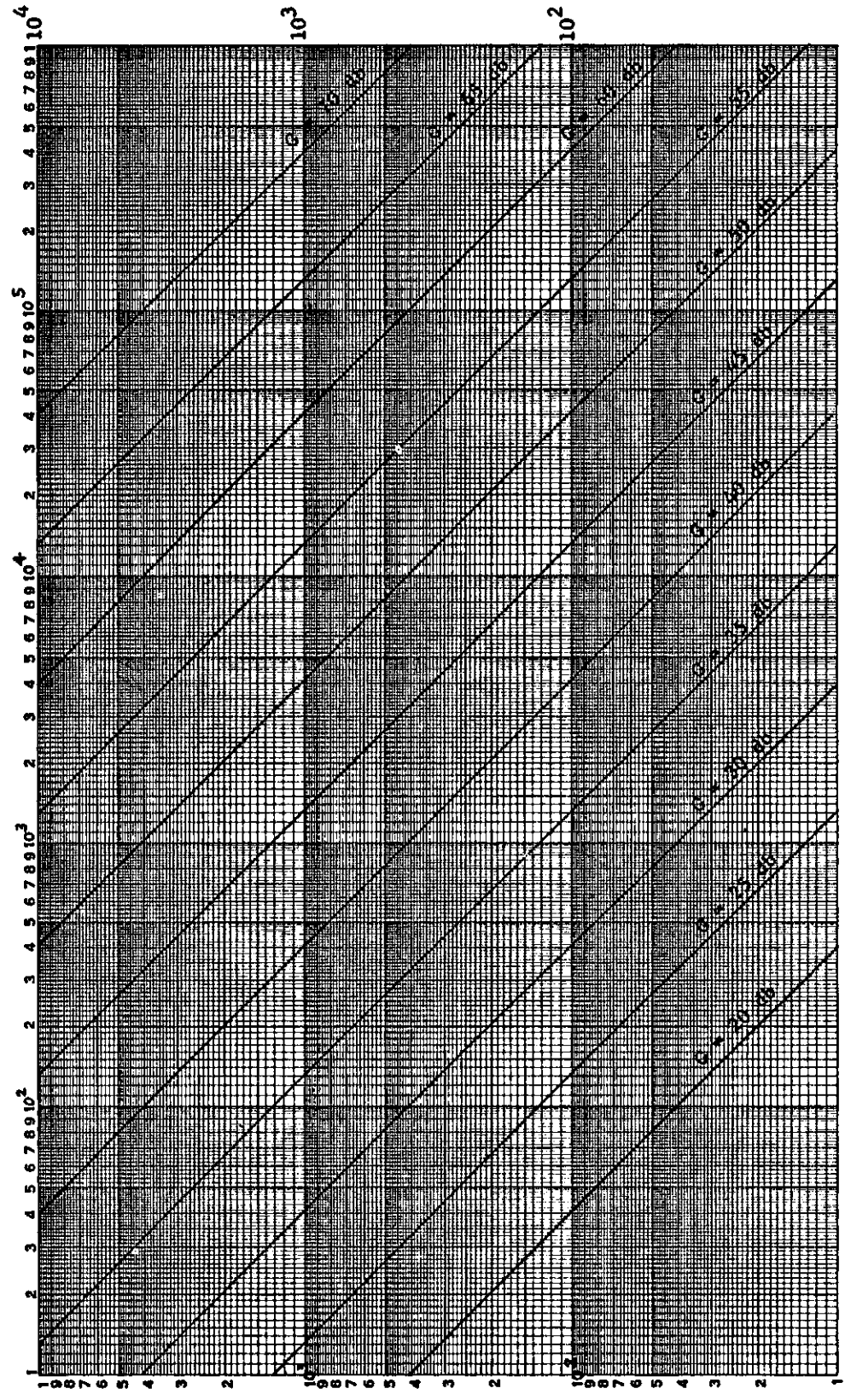
For a maximum power density of 10mw/cm^2 (safe limit for humans) the range at which this occurs may be expressed as

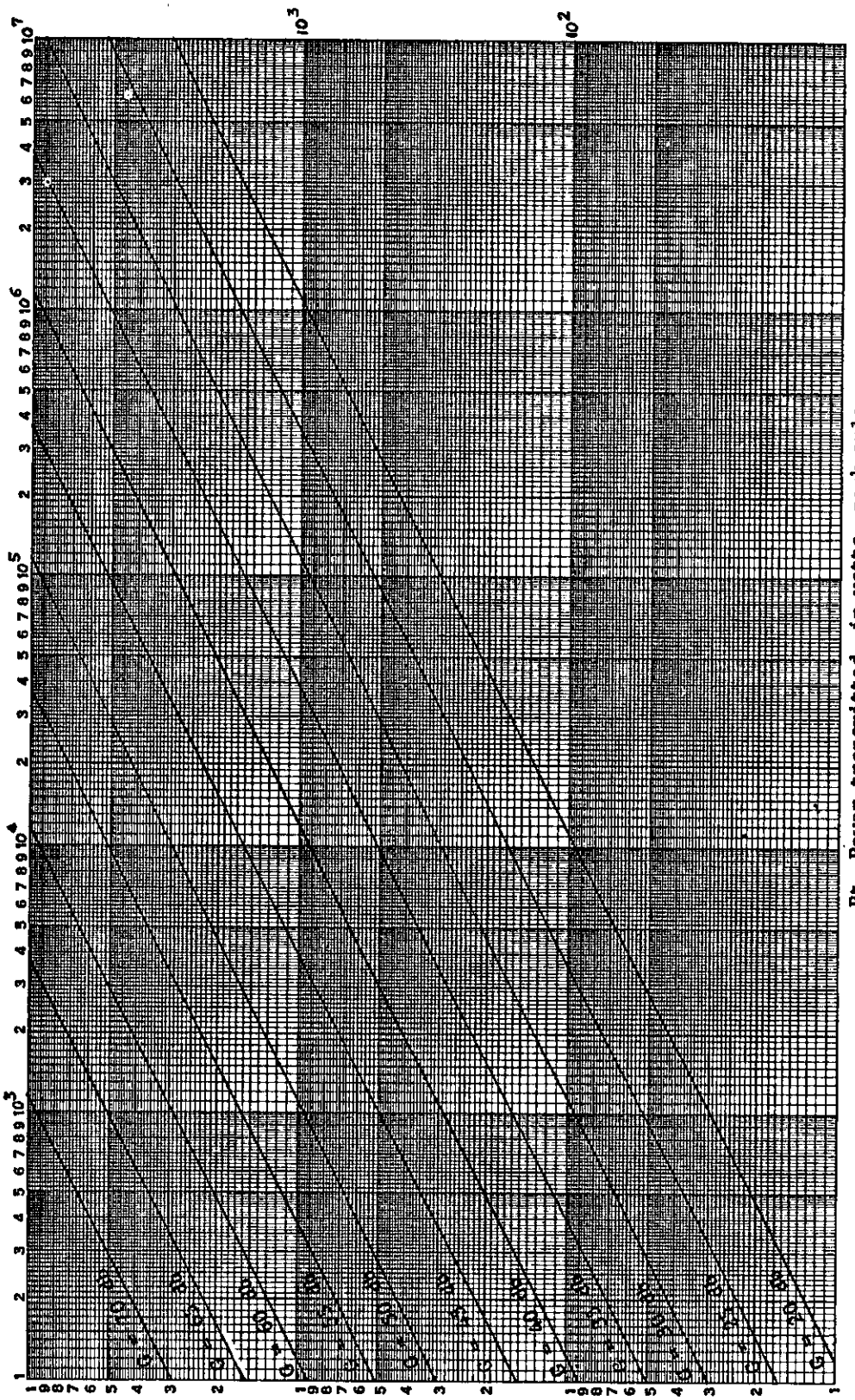
$$r = \left(\frac{GP}{4\pi(100)}\right)^{1/2} \times (3.28) \text{ feet} \qquad (3)$$

3. Power Density Calculations. The above formula may be used directly or graphs similar in manner to the attached may be used. In either case the following procedure should be followed.

   a. Calculate Ro (graph or formula (2)).

   b. Calculate r for 10 mw/cm^2 (graph or formula (3)). If r is less than Ro, the power density limit of 10 mw/cm^2 is no where exceeded in the far field. The maximum power density that could occur anywhere within the near field may then be calculated from formula (1) and will be less than 10 mw/cm^2.


Ro, Distance to near field-far field intersection in feet
Frequency in megacycles
Distance to Intersection of Near and Far Fields



U. S. GOVERNMENT PRINTING OFFICE : 1970 O - 381-394

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Washington, D.C. 20590

Official Business

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POSTAGE AND FEES PAID
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