Non-Ionizing Radiation: Standards and Regulations

Bob Curtis,
OSHA
Salt Lake Technical Center

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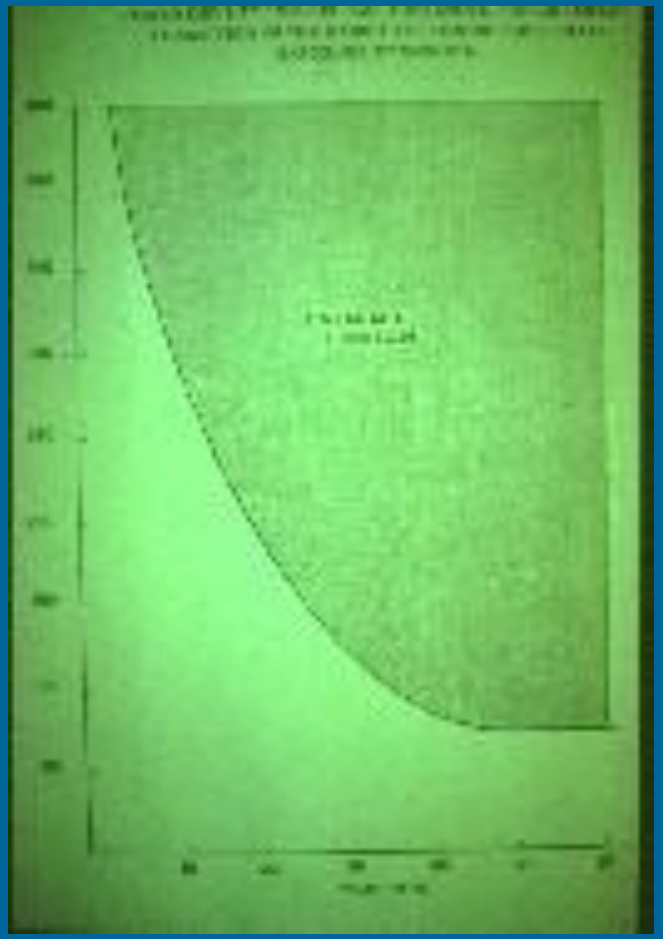
Power Density vs. Time to Generate Cataracts



Threshold @ 40 min

= 100 mW/sq.cm.

Safety factor of 10

= 10 mW/sq.cm.

Applicable OSHA Standards

- 23 States have their own OSHA Standards
  - Standards must be at least as strict as Feds
  - Most copy Federal standards & interpretations
  - Some require a Safety and Health Program
- 1910.97 - Non-Ionizing Radiation
  - 10 mW/sq.cm, 6 min. average, 10MHz-100GHz
  - No spatial averaging
  - Uses voluntary language of 1966 ANSI
  - Mandates look of RF Sign

Applicable OSHA Standards (cont.)

- 1910.268 - Telecommunication Industry
  - Primarily safety requirements, such as electrical
  - Mandates 1910.97 compliance for 1-300 GHz
  - Describes “Tagout” of antenna 3-300 MHz
- 1926.54, 20 - Construction Industry
  - Includes tower erection, repairs and painting
  - Limits MW to 10 mW/sq.cm. (no averaging)
  - Requires Programs to provide safe work to employees and contractors; includes inspection

OSHA Exposure Standards are Dated

- Construction Laser standard does not include Laser Classification and controls
- RF Exposure Limit is from 1966 ANSI
  - Not frequency dependent
  - Does not address induced current limits
- Incomplete on Hazard Communication
  - Describes RF Sign but not where to use it
  - One Warning sign for all conditions
- Incomplete on RF Safety Program Elements

Applicable OSHA Standards (cont.)

- 1910.147 - Lockout/Tagout of Power
  - Requires lockout or tagout of power during maintenance to prevent excessive exposures
- 1910.132 - Personal Protective Equipment
  - Requires hazard assessment to select appropriate PPE
  - Interpretation letter addresses RF Clothing
- 1910.145, 1926.200 - Signs and Tags
  - Use signs to warn of hazards

Applicable OSHA Standards (cont.)

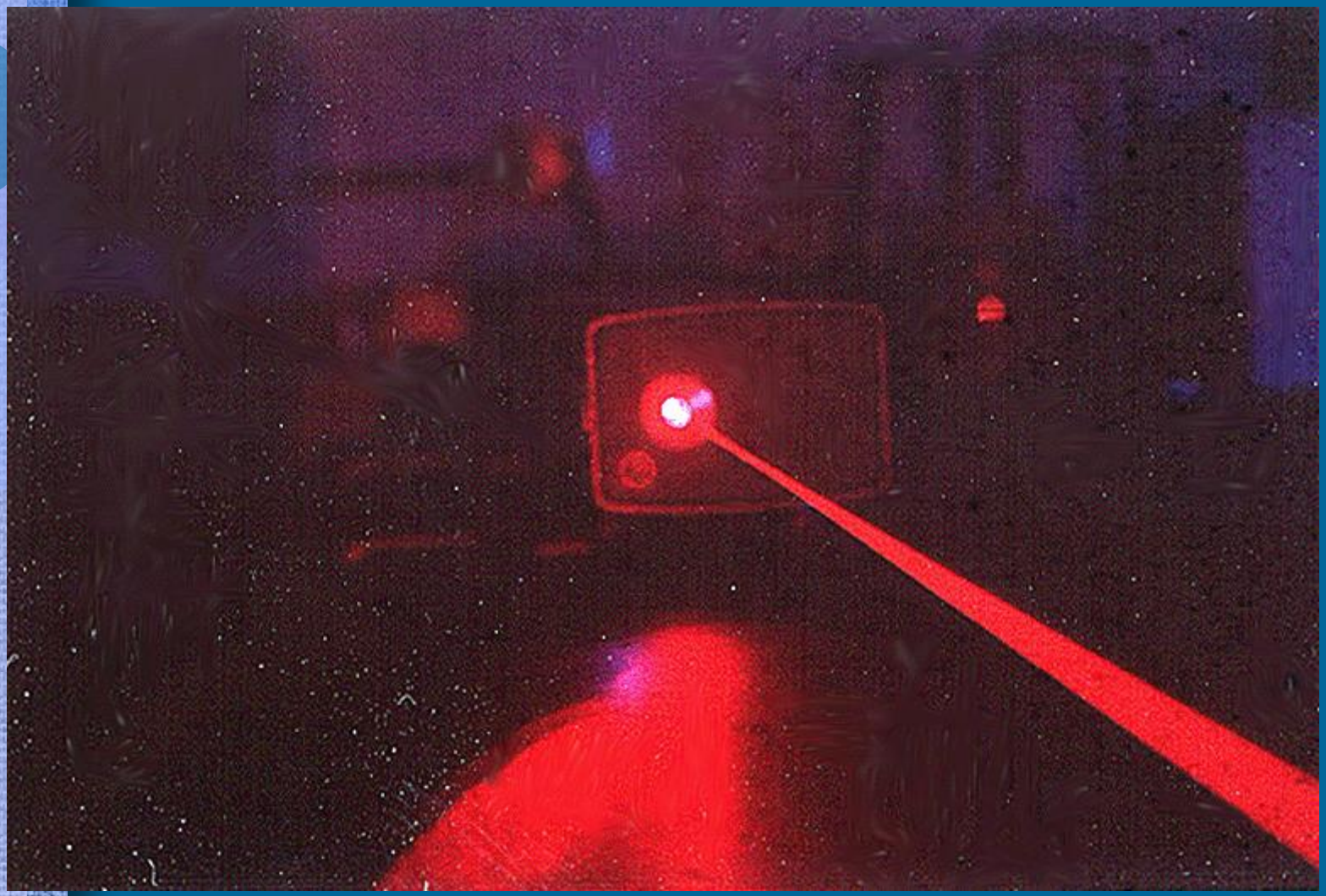
- 1904 - Record Keeping
  - Log of injuries and illnesses, accidents
- 1910.1020 - Access to Employee Exposure and Medical Records
- 1926.20 – Construction Safety Plan
- Section 5(a)(1) of OSH Act
  - Requires a safe and healthful workplace free of recognized serious hazards

Consensus Standards: ACGIH TLVs

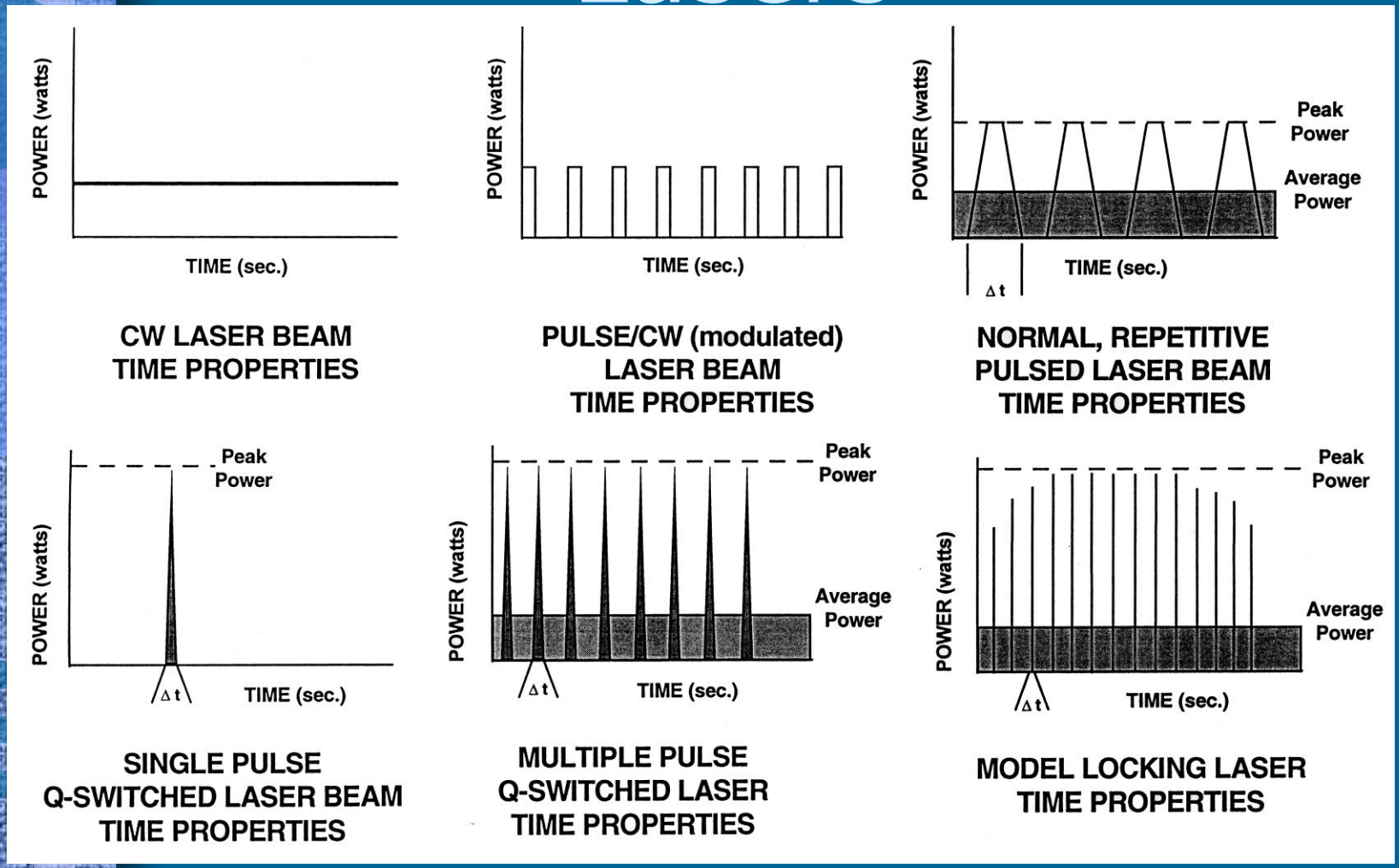
- Ultraviolet Radiation
- Light and Near-Infrared Radiation
- Lasers
- Radiofrequency/Microwave Radiation
- Sub-RF and Static Electric Fields
- Sub-RF Magnetic Fields
- Static Magnetic Fields

Consensus Standards: ANSI Laser Standards

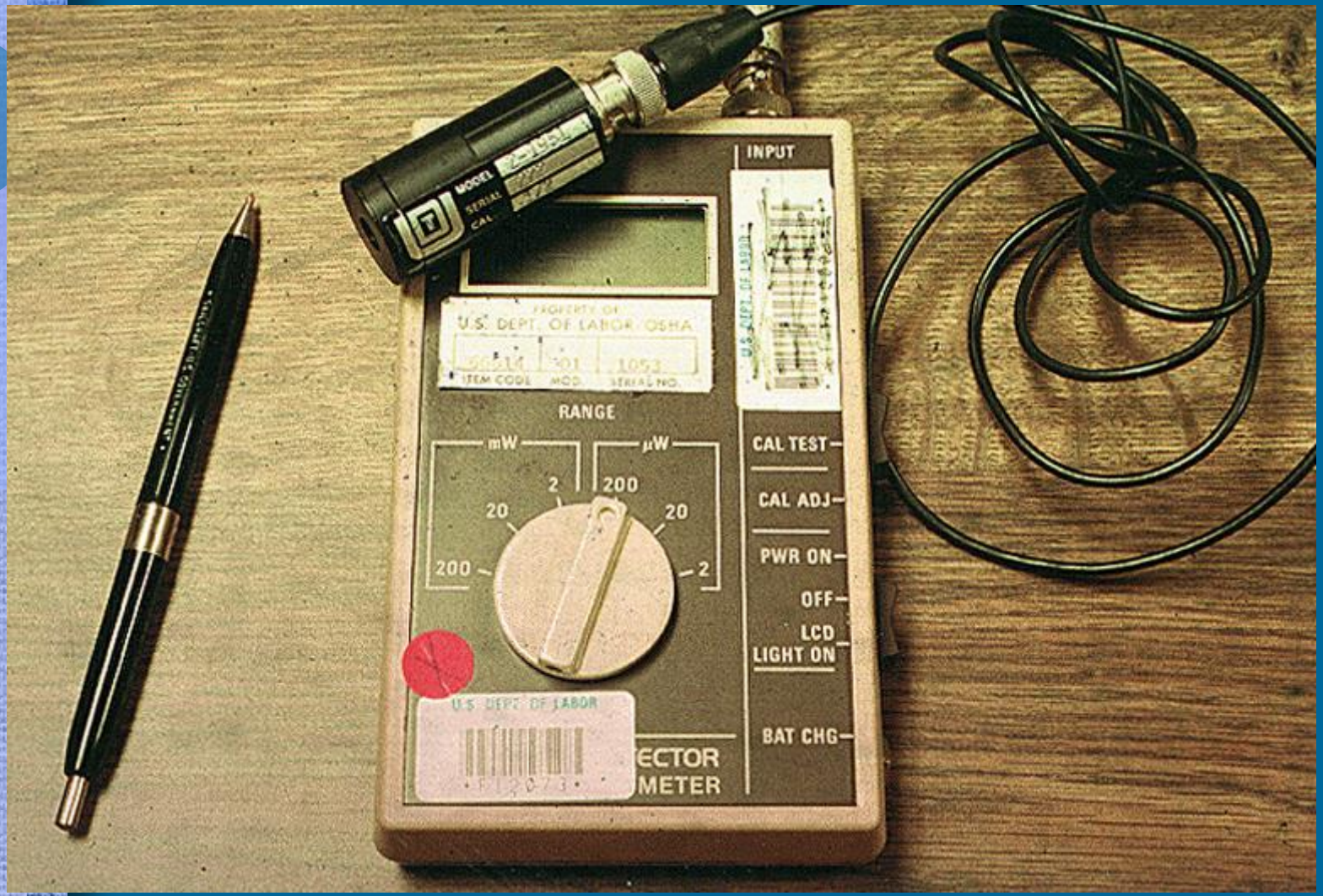
- Z136.1-2000: Safe Use of Lasers
- Z136.5-2000: Safe Use of in Educational Institutions
- Z136.6-2000: Safe Use of Lasers in an Outdoor Environment
- Z136.3–1996: Safe Use of Lasers in Health Care Facilities
- Z136.2-1997: Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources



Continuous vs. Pulsed Lasers



Thinner pulses give higher peaks for same average Power.


INPUT
PROPERTY OF
U.S. DEPT. OF LABOR OSHA
ITEM CODE
MOD
SERIAL NO.
RANGE
mW
µW
2
20
200
200
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2
CAL TEST
CAL ADJ
PWR ON
OFF
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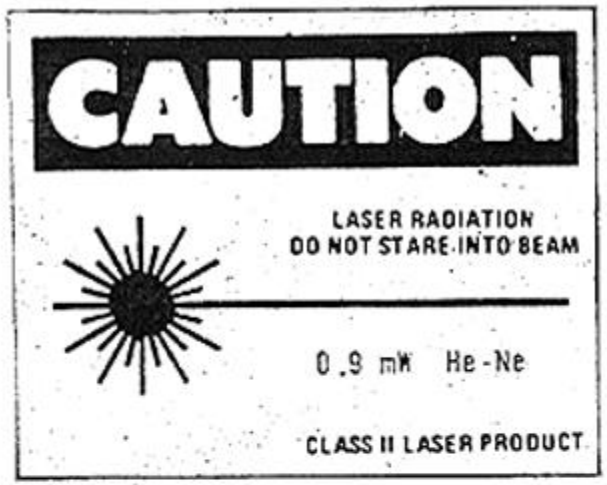
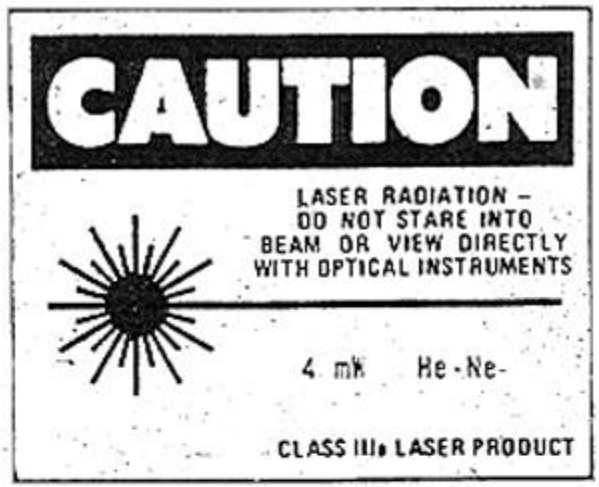
LIGHT ON
BAT CHG
U.S. DEPT. OF LABOR
ECTOR
METER


CAUTION
LASER RADIATION
DO NOT STARE INTO BEAM
0.9 mW He-Ne
CLASS II LASER PRODUCT

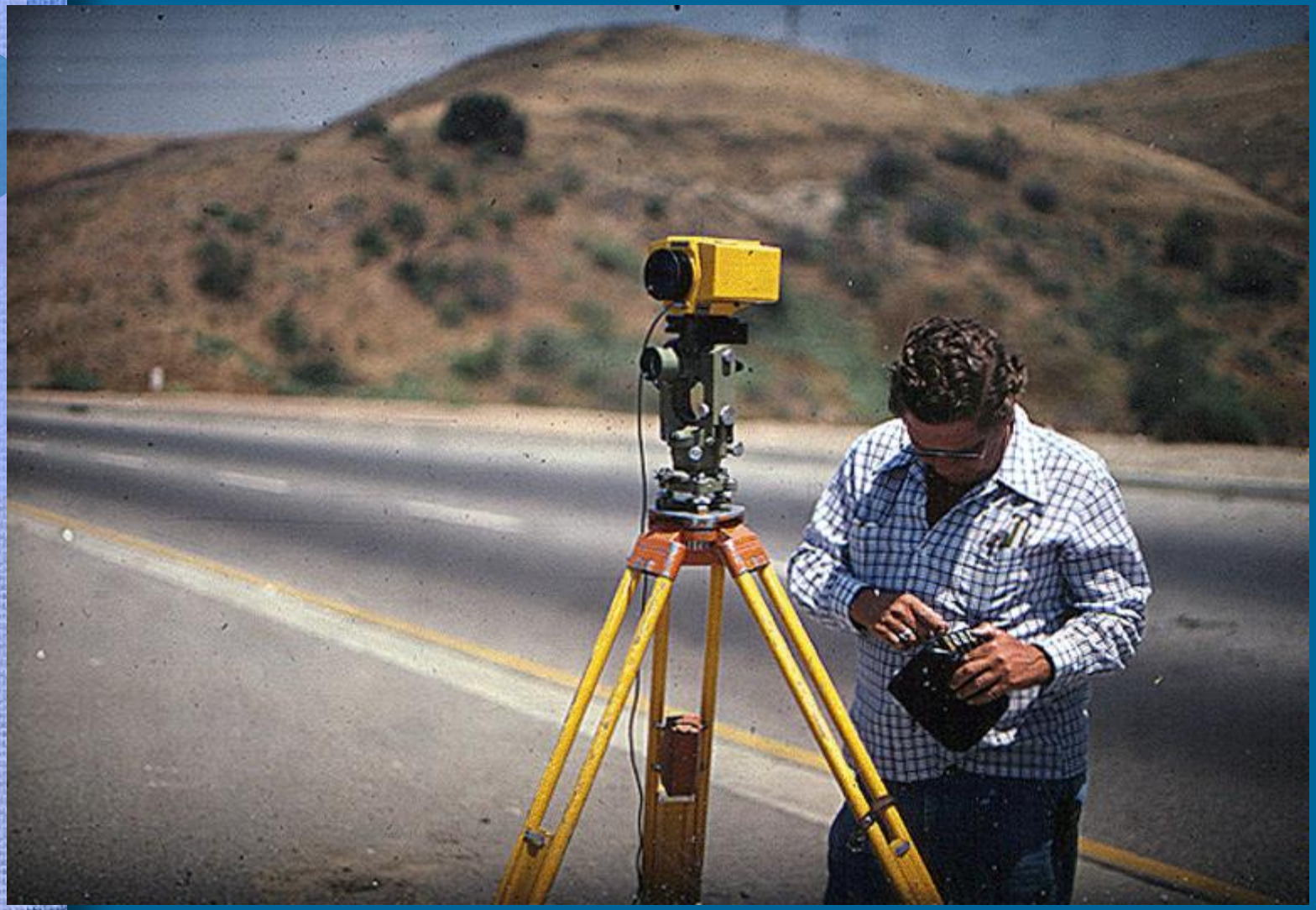

CAUTION
LASER RADIATION –
DO NOT STARE INTO
BEAM OR VIEW DIRECTLY
WITH OPTICAL INSTRUMENTS
4 mW He-Ne-
CLASS IIIb LASER PRODUCT

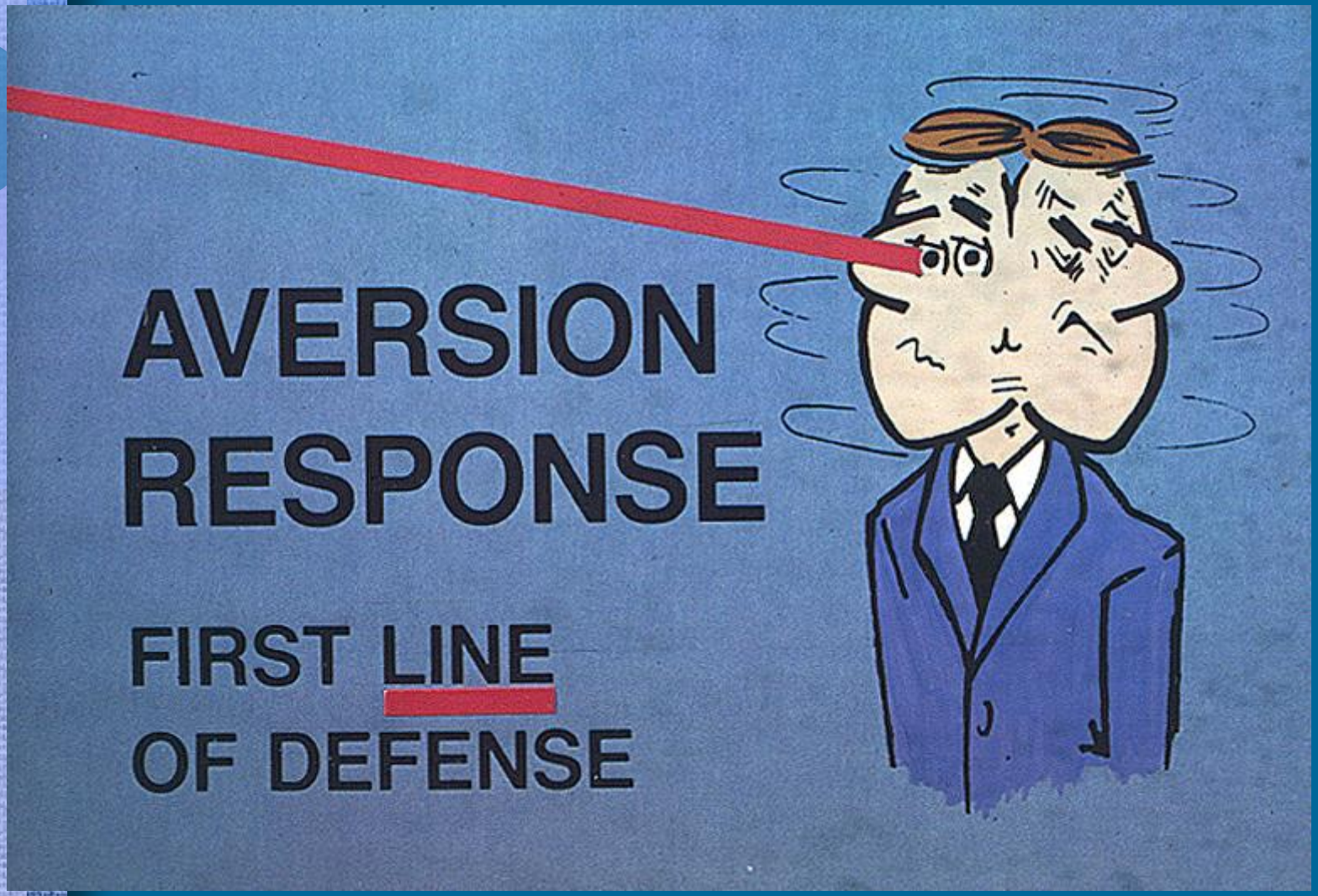

DANGER
LASER RADIATION –
AVOID DIRECT EXPOSURE
TO BEAM
50 mJ 1064 nm
20 ns Pulse
CLASS IIIb LASER PRODUCT

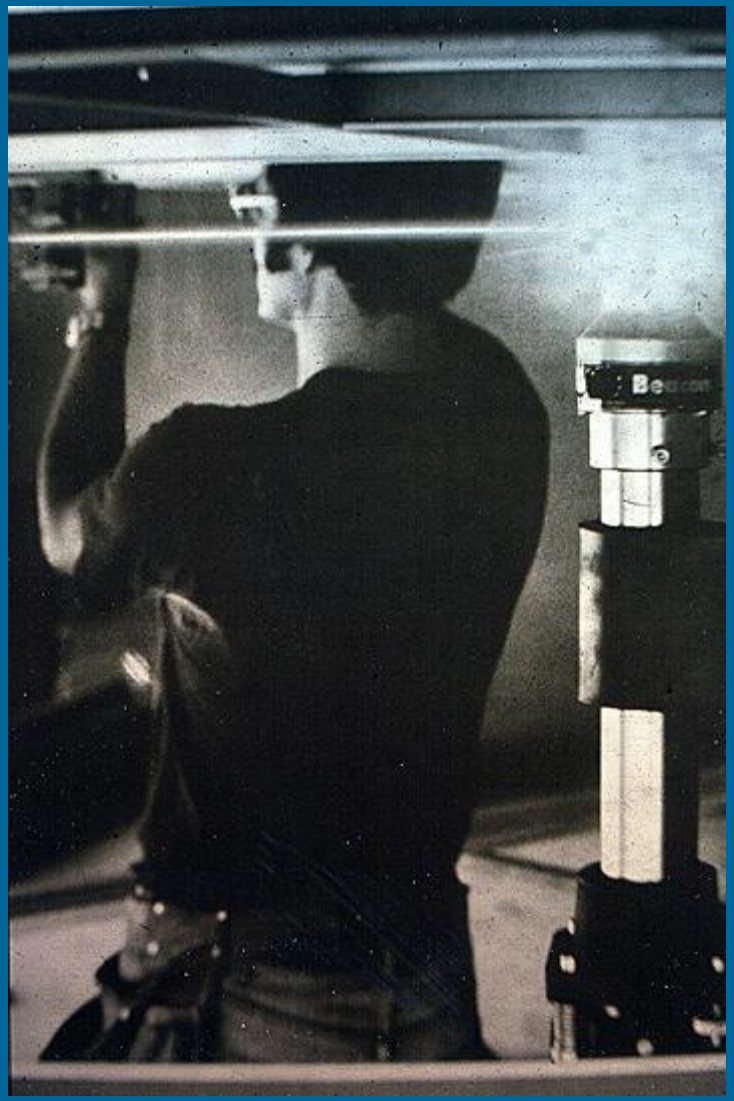

DANGER
LASER RADIATION –
AVOID EYE OR SKIN EXPOSURE
TO DIRECT OR SCATTERED
RADIATION
50 W CO_2
CLASS IV LASER PRODUCT

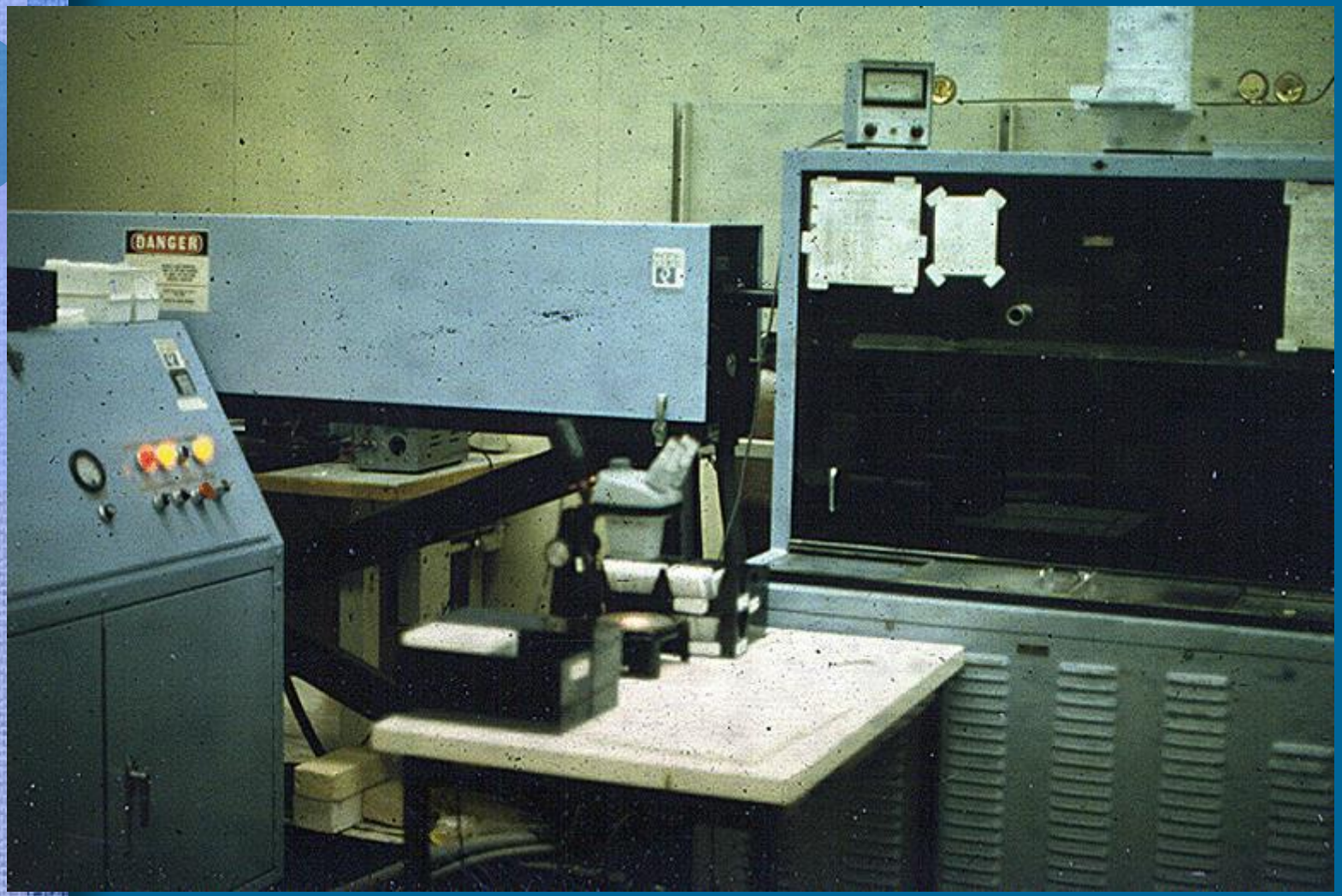
Laser Classes

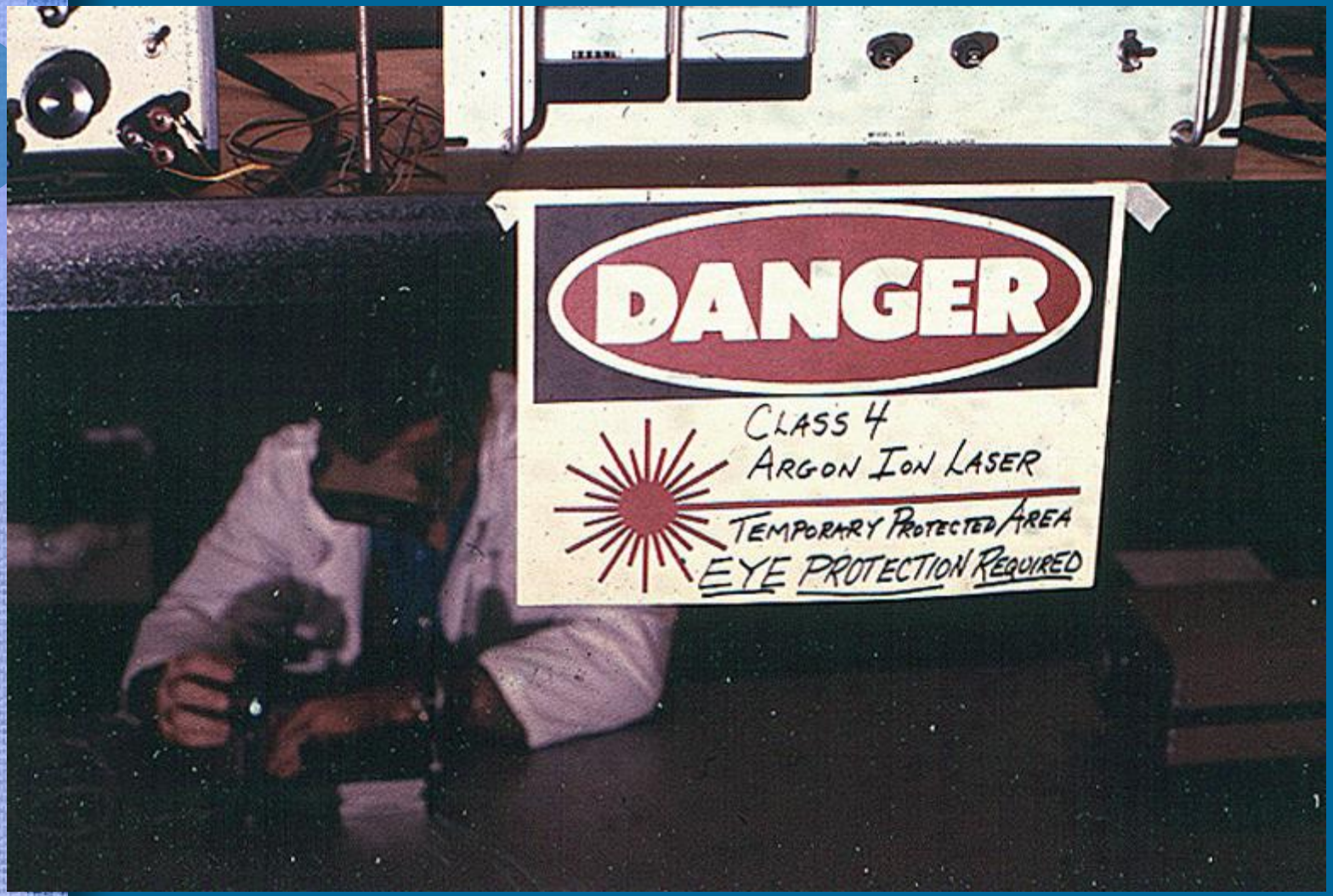
- Class I: Safe – no label needed
  - Do not disassemble Class I systems
- Class II: Visible lasers.
  - Aversion response provides protection.
  - Prevent staring into beam
- Class IIIa: Visible lasers.
  - Limit eye exposure from focusing lenses
- Class IIIb: No eye exposure
- Class IV: No eye or skin exposure.
  - Hazard from diffuse reflections
  - Potential fire hazard

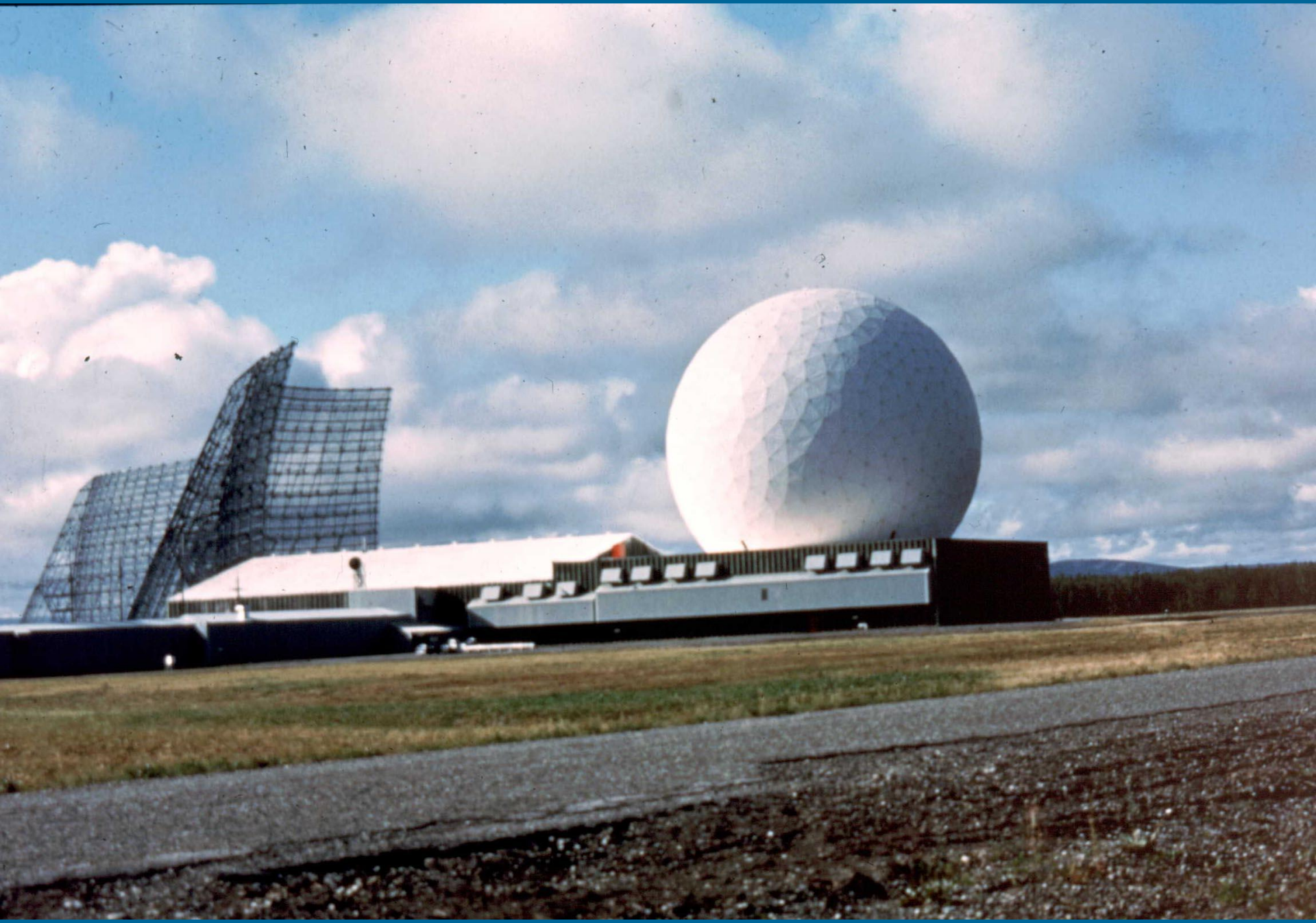







DANGER


DANGER
CLASS 4
ARGON ION LASER
TEMPORARY PROTECTED AREA
EYE PROTECTION REQUIRED



RF Consensus Standards

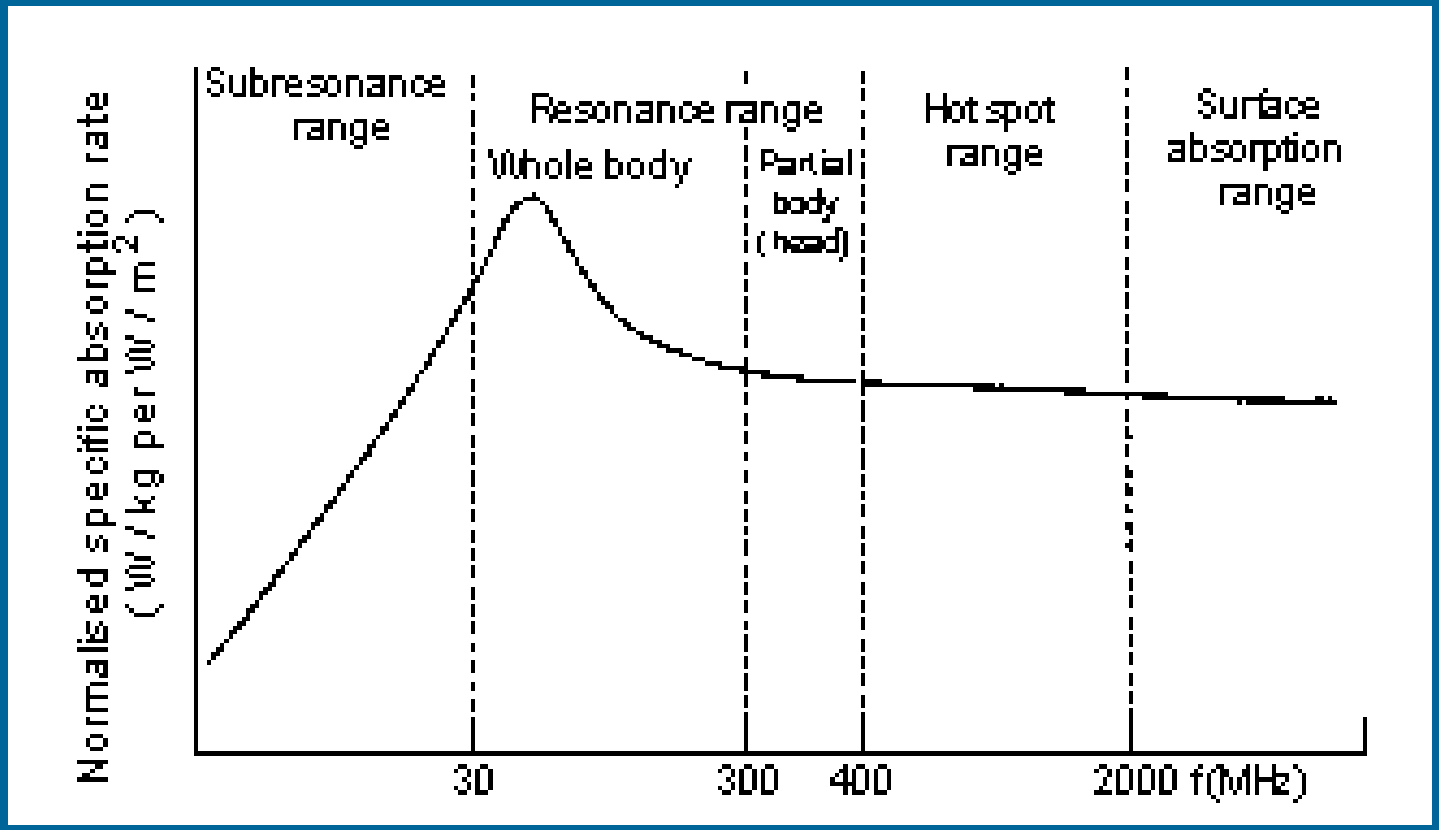
- IEEE/ANSI (U.S.)
  - C95.1 - RF/MW Exposure limits
  - C95.2 - Signage and S&H programs
  - C95.3 – Measurement
  - Separate ELF standard
- ICNIRP (International)
  - Single standard 1 Hz to 300 GHz
- ACGIH TLV's (US)
  - RF/MW, Sub-Resonant E & H

Basis of Current RF Standards

- Behavioral disruption threshold
- Limit temperature increase to 1 degrees C
- 1-4 W/kg SAR
- 10-fold safety factor

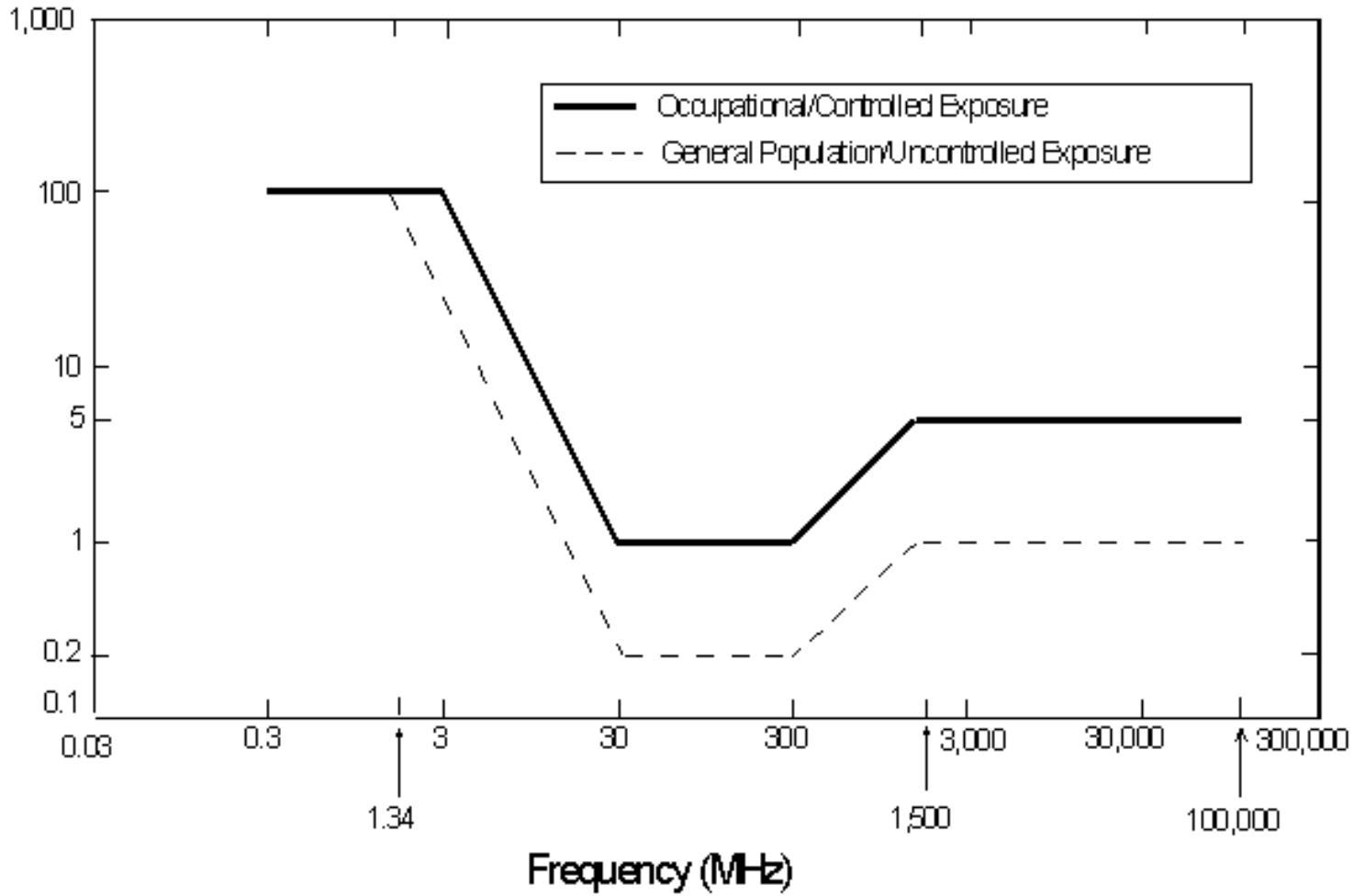
Specific Absorption Rate

Absorbed power in Watts/kg



SAR vs. Frequency

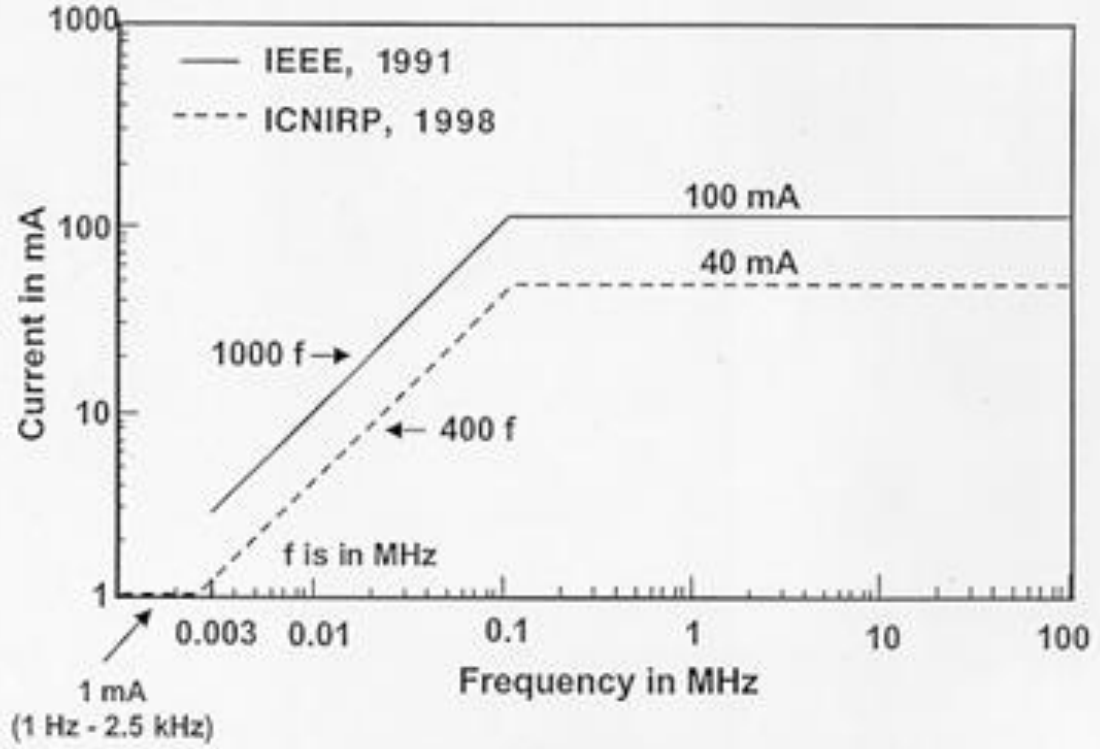
Figure 1. FCC Limits for Maximum Permissible Exposure (MPE)



RF Exposure Standards are Typically Based on 6 min. TWA

- Excursions allowed if 6 min time weighted average is within limits
- Up to 30 min intervals used for public exposure standards

Maximum Contact Current for Occupational (Controlled) Environment



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Use of ANSI vs. OSHA vs. FCC Standards

- Newer, more restrictive standards can be used.
- Meeting SAR limits is often easier than field limits.
- New standards allow for spatial averaging, but you have to adopt the whole package.

Use of ANSI vs. OSHA vs. FCC Standards (cont.)

- Convenient to adopt FCC (with RF current limits).
- OSHA state programs may dictate, but usually defer to newer standards.

Dosimetric Parameters Used for ICNIRP Basic Restrictions

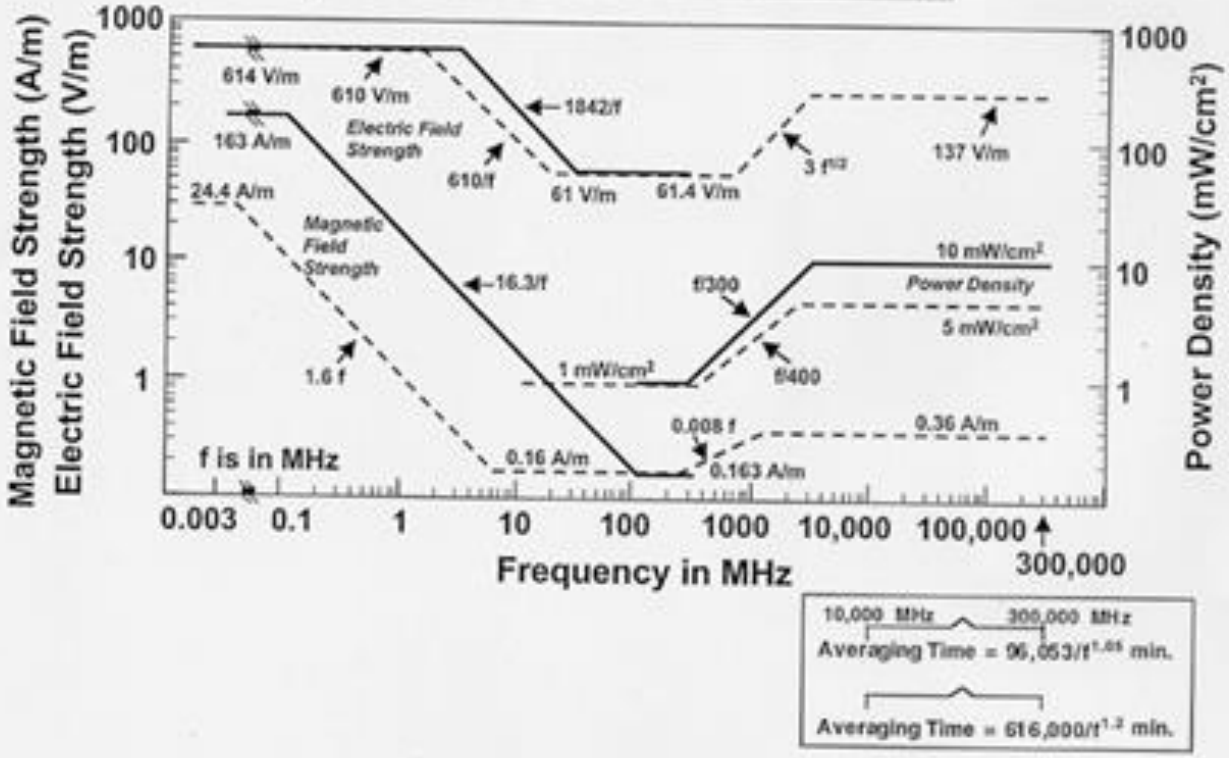
Frequency Range	Parameter (units)
1 Hz → 10 MHz	J (A/m^2)
1 Hz → 110 MHz	I (A)
100 kHz → 10 GHz	SAR (W/kg)
10 GHz → 300 GHz	S (W/m^2)
Pulsed Fields:	
300 MHz → 10 GHz	SA (J/kg)

Same Basis, but Standards Differ

- General population vs. Controlled RF Sites
- Localized exposure limits (spatial averaging)
- Time averaging
- Special exclusions, such as low-power devices, peak exposures.

Maximum Permissible Exposure (MPE) for Occupational (Controlled) Environment

(— IEEE, 1991; - - - ICNIRP, 1998)



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Safety & Health Programs

- OSHA promotes implementing an effective Safety & Health Program
- Many State OSHA's Already Require
- Required for Federal Agencies
- Required by International Standards (ISO)
- Good Employers will Implement Regardless of OSHA

What is Needed? Site-Specific RF Program

- Work site Safety and Health Programs should include an RF Program if significant exposures are possible.
- A priority, because S&H Programs can be very effective in preventing excessive exposures.

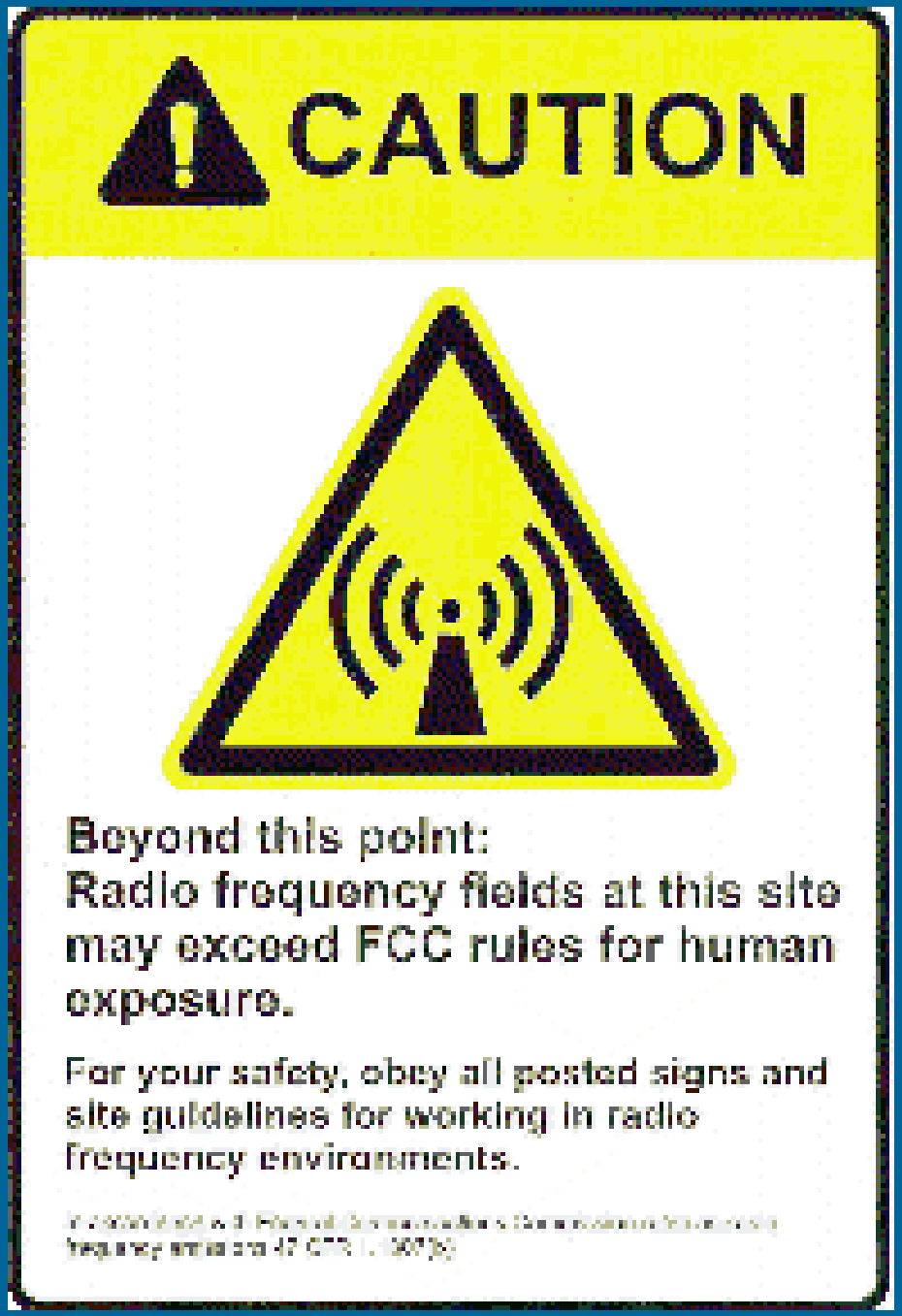
Basic Requirements

- Implement an RF program where exposures exceed FCC “General Population” or Public limits (see following slides).
- The RF Program must ensure employee exposure does not exceed FCC “Occupational” limits.

Hazcom Program should exist for “Uncommonly High” Fields, such as:

>50 mG whole body ELF
>Uncontrolled limits of FCC

- Perimeter of FCC Uncontrolled Limits



- Perimeter of Controlled Limits indicating need for protective measures (e.g., time averaging)

- Time averaging is not feasible to prevent exposures > MPE’s

Posted to mark prohibited access without power-down.

PPE is not sufficient.

New Developments Confound Consensus Building

- ICNIRP Standard being adopted more
- Precautionary Principle being adopted by some countries and local governments.
- Regulations regarding Mobile phones & Cellular Tower Sites

Comprehensive Standard vs. Exposure Limit

- Combination of practices and exposure limits gives more guidance (e.g. ANSI Laser Stds.)
- Exposure limit can be less restrictive.
- E.g. Protection for all persons vs. exclusions for target populations.
- For each exclusion, you need a program that checks the criteria.

Predictions

- Balloting next year on new limit.
- Consensus will drive the standard to be similar to existing version.
- US will continue to drift apart from other countries which will adopt precautionary principle.
- The use of cell phones will continue to rise dramatically.
- Other needed RF standards will proceed, but slow in development.

Slow Progress on Needed Standards

- RF Safety Program
- RF Awareness (Signs)
- Medical Surveillance and Response
- Measurement Procedures for induced currents
- Criteria for RF Protective Clothing
- Spark Discharge
- Cellular Phones

Extent of RF Program is Based on Exposure

- Locations are Categorized (I-V) based on potential exposures.
- Many RF exposure situations require no, or a limited RF Safety Program. (Categories I-II)
- More extensive program elements for higher exposure categories.

Controls/Administrative (cont.)

	I	II	III	IV	V
Personal Monitors	**NN**	**No**	**Opt.**	**Opt.**	**No**
Incident Response	**NN**	**Yes**	**Yes**	**Yes**	**Yes**
Medical Devices & Implants	**Personal Respon-sibilty**	**Personal Respon-sibility**	**Yes, make aware**	**Yes**	**Yes**
Maintenance of Controls	**NN**	**Yes for Public**	**NN for work.**	**Yes**	**Yes**

Proposed Thresholds

- A - Adverse Effect
- B - Effect Preliminary to a Known Adverse Effect
- C - Effect, but Unknown Human Health Consequence

- X - Known Non-Adverse Effect

For More Information www.osha.gov

- Subject Pages on
  - Lasers
  - RF/Microwave
  - ELF
- Includes PowerPoints and Lecture Outlines

Miscellaneous Slides: Setting Standards

RF Standard Development

- ANSI C95.1-1966 (OSHA Adopted)
- ANSI 1982 (Frequency dependent)
- ANSI/IEEE 1992 (Two-Tiered)
- IEEE SCC-28 in process.

IEEE “Culture”

- Engineers/Biologists - few IH’s
- Many representatives of Industry and DoD
- Few Public Safety Regulators
- Standards Based on Known Adverse Health Effects

Process for Standard Development

- Literature Review
  - Engineering
  - Animal and Cellular (In Vitro, In Vivo)
  - Epidemiology
  - Mechanisms
- Risk Assessment
- Consensus

Problems

- Review process going slow.
- Risk Assessment proceeding.
- Difficulty in getting consensus on basic concepts for a new standard.

Major Issues to Resolve

- Selection of adverse effect level.
- Basis for local SAR limit.
- Acute vs Chronic exposures.
- Time Averaging
- Uncertainty Factor
- One limit vs Public & Worker limits
- Action Limit and RF Program

- Exposures between B and C occur within known gaps in research, so “Precautionary Principle” or ALARA may be appropriate.
- Precautionary Principle not justified below C level where most exposures occur.

Right to Know

- More lenient on threshold if people given choices.

Purpose and Scope of the ICNIRP Guidelines

- Develop an internally consistent set of exposure guidelines that cover the nonionizing radiation spectrum from 1 Hz to 300 GHz
- The guidelines are intended to provide adequate protection against known adverse impacts on human health resulting from direct and indirect EMF exposure effects.

UK Stewart Commission

- Preliminary evidence that (phones) may cause, in some cases, subtle biological effects… (This) does not necessarily mean that health is affected.
- Advocates the "Precautionary" approach until more information.
- Specifically: Labeling of phones; Reduce children use.
- Most points accepted by UK gov't.

1910.268(p)(2)

Accessible areas associated with microwave communication systems where the electromagnetic radiation level **exceeds** the radiation protection guide given in § 1910.97 **shall be posted** as described in that section. The lower half of the warning symbol shall include the following:

Radiation in this area may exceed hazard limitations and special precautions are required. Obtain specific instruction before entering.

1910.268(p)(3)

Protective measures. When an employee works in an area where the electromagnetic radiation exceeds the radiation protection guide, the employer shall institute measures that **insure that the employee's exposure is not greater than that permitted by the radiation guide**. Such measures shall include, but not be limited to those of an administrative or engineering nature or those involving personal protective equipment.

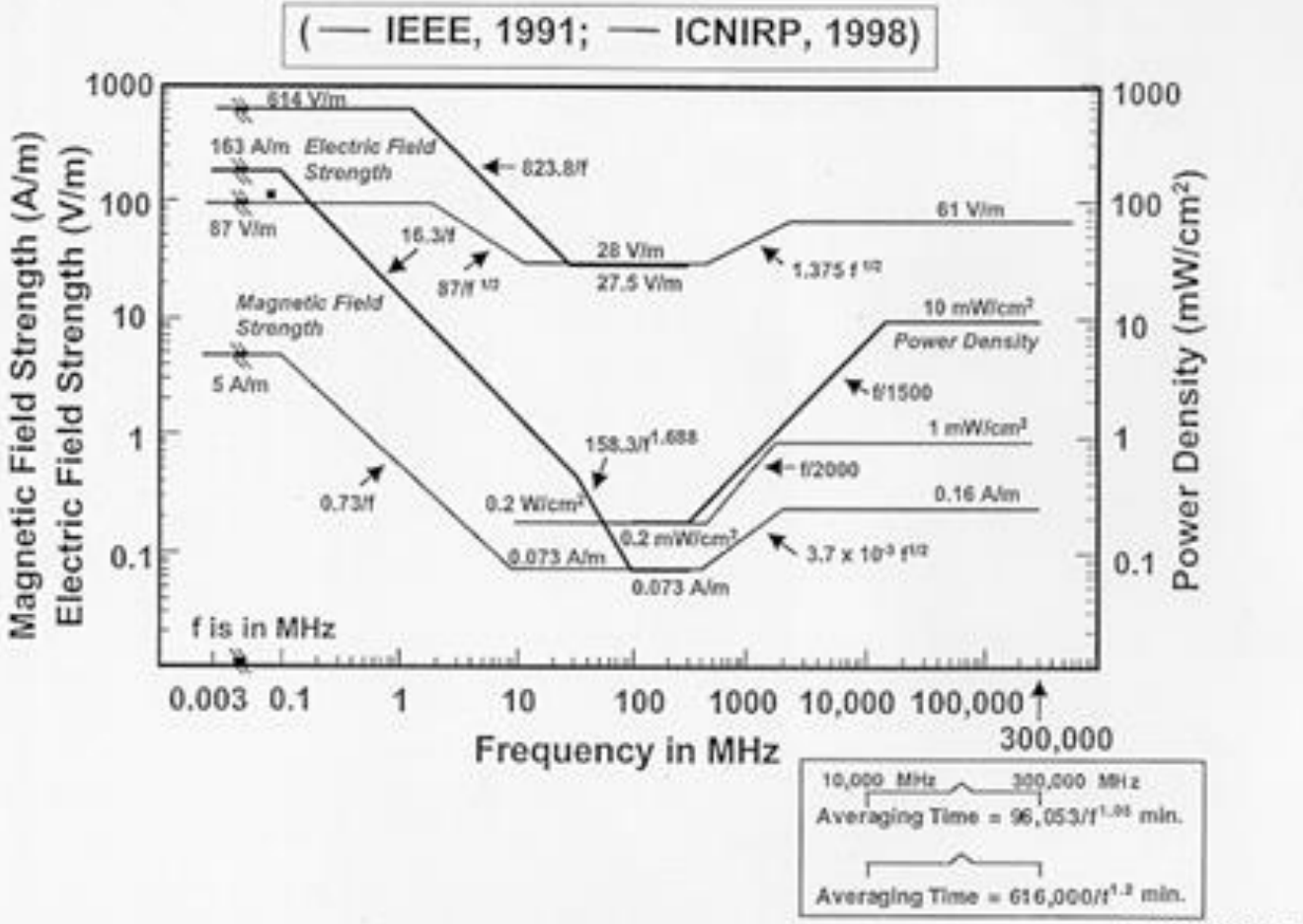
"Modifications" to OSHA Standards

- OSHA Directives to Inspectors and Official Interpretation Letters
  - Acceptance of newer ANSI RF Sign
  - ANSI Laser Standard Recommended in lieu of outdated OSHA standard.
  - Guidance for using RF PPE
- Education of Employers, Employees, and Compliance Staff

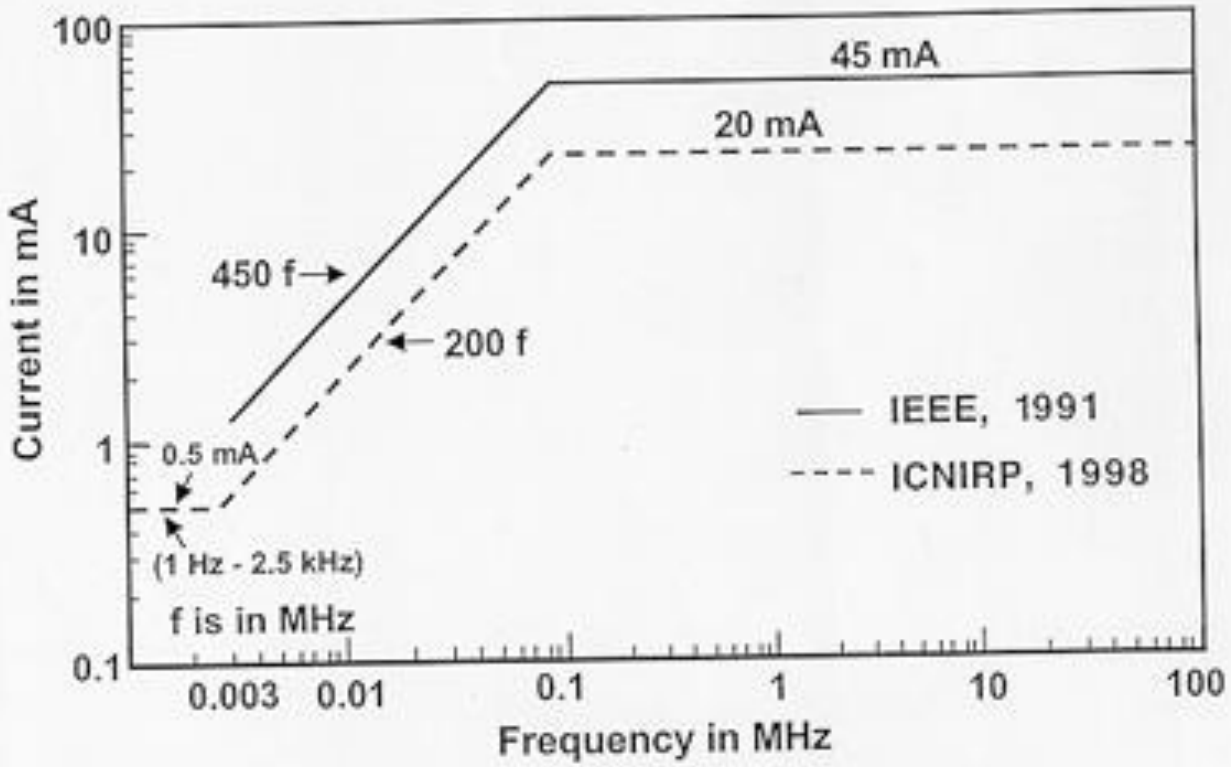
Basis for the Safety Factor

- Thermally stressful environments
- Use of alcohol, some medications etc.
- Thermally sensitive
- Normal factor for Public safety due to unknowns in science, health effects, etc.

Maximum Permissible Exposure (MPE) for Public (Uncontrolled) Environment



Maximum Contact Current for Public (Uncontrolled) Environment



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IEEE Gives Guidance about Pulsed RFMW

- Pulsed limit = $\frac{\text{IEEE cw limit x IEEE averaging time (in secs)}}{\text{5 x pulse duration (in secs)}}$
- Peak E field < 100 kV/m
- Cw limits apply to situation in which there are more than five pulses during the averaging time

IEEE Gives Guidance about Pulsed RFMW (cont.)

- Pulsed mw creates mini shock waves which radar operators have reported as clicking sound: may be responsible for eye and neuropharmacological effects reported for pulsed mw according to Lin

Changes to C95.4-1992 (Supplements)

- Induced current measurements are not necessary for frequencies < 450 kHz (controlled) and < 200 kHz (uncontrolled), or if field strengths are low (e.g., 16% at 27 MHz).
- Changes to the averaging time for RF currents, including prohibition of RF burns.
- Definition of Spatial Average

Changes to C95.4-1992 (Supplements) (cont.)

- Definition of Averaging Volume for Spatial-Peak SAR
- Establishes minimum measuring distance of 5 cm.
- Defines radiated power.

Spatial Averaging

- ANSI standard is confusing regarding partial-body vs. non-uniform exposure.
- Exception for testes and eyes (See interpretation).
- OSHA standards, based on old ANSI, does not allow for spatial averaging.

Table 1. LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

(A) Limits for Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $|E|^2$, $|H|^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	($900/f^2$)*	6
30-300	61.4	0.163	1.0	6
300-1500	--	--	f/300	6
1500-100,000	--	--	5	6

(B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $|E|^2$, $|H|^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	($180/f^2$)*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz

*Plane-wave equivalent power density

Miscellaneous Slides: RF Exposure Classes

Proposal for ANSI RF Program Standard

- **Class I areas: No signs needed.**
- **Class II areas: Notice Signs are suggested**
- **Class III areas: Caution Signs are required**
- **Class IV areas: Warning Signs are required**
- **Class V areas: Danger Signs are required**

Category I Areas

- Locations where RF fields are too weak to cause exposures greater than the FCC general population (public) limits.
- No dependence on controls, including time averaging.
- NO RF SAFETY PROGRAM NEEDED!!

Category II Areas

- Potential exposures are controlled to ensure compliance with FCC Public limits.
- Must maintain controls, such as time averaging and shielding, to remain below public limits.

Category III Areas

- Locations where RF fields are too weak to cause exposures greater than the FCC Occupational limits.
- No dependence on controls, including time averaging.

Category IV Areas

- Potential exposures are controlled to ensure compliance with FCC Occupational limits.
- Must maintain controls, such as time averaging and shielding, to remain below Occupational limits.

Category V Areas

- Exposure conditions which can not be controlled to comply with FCC Occupational limits.
- Includes surfaces which will cause serious RF burns if contacted.

Summary Tables of Program Elements Needed for Each Exposure Category

Administrative

	I	II	III	IV	V
Policy	**NN**	**Yes**	**Yes**	**Yes**	**Yes**
Accountable Person	**NN**	**Yes**	**Yes**	**Yes**	**Yes**
Documentation	**NN**	**Yes, for incidents**	**Yes**	**Yes**	**Yes**
Employee Involvement	**NN**	**No**	**Opt.**	**Yes**	**Yes**
RF Safety Committee	**NN**	**No**	**Opt.**	**Opt.**	**Opt.**
Procurement of RF Source Equipment	**NN**	**Yes**	**Yes**	**Yes**	**Yes**

Identification of Potential Hazards

	I	II	III	IV	V
Inventory of RF Sources	**NN**	**Yes**	**Yes**	**Yes**	**Yes**
Exposure Assessment	**NN**	**Initial, + after change**	**Initial, + after change**	**Yes**	**Yes**

Controls/Engineering

	I	II	III	IV	V
Utilize low exposure Equip. & Site Configuration	**NN**	**Yes**	**Yes**	**Yes**	**Yes**
Access Restriction	**NN**	**Opt.**	**Opt.**	**Opt.**	**Yes**
Maintenance of Controls	**NN**	**Yes**	**Yes**	**Yes**	**Yes**

Controls/Administrative

	I	II	III	IV	V
Use of Signs	**NN**	**Yes**	**Yes**	**Yes**	**Yes**
Access Restriction	**NN**	**Opt.**	**NN**	**Opt.**	**Yes**
Work Practices	**NN**	**No**	**Opt.**	**Opt.**	**Opt.**
Control of Source Power (LOTO)	**NN**	**No**	**No**	**Opt.**	**Opt.**

Controls/Administrative (cont.)

	I	II	III	IV	V
Personal Monitors	**NN**	**No**	**Opt.**	**Opt.**	**No**
Incident Response	**NN**	**Yes**	**Yes**	**Yes**	**Yes**
Medical Devices & Implants	**Personal Respon-sibilty**	**Personal Respon-sibility**	**Yes, make aware**	**Yes**	**Yes**
Maintenance of Controls	**NN**	**Yes for Public**	**NN for work.**	**Yes**	**Yes**

Personal Protective Equipment

	I	II	III	IV	V
Selection of PPE	**NN**	**No**	**No**	**Opt.**	**When used**
Maintenance, Use, & Accessibility	**NN**	**No**	**No**	**When used**	**When used**

Training

	I	II	III	IV	V
Explanation for RF Exposure Limits	**NN**	**NN**	**Yes**	**Yes**	**Yes**
Use & Maintenance of Controls	**NN**	**Yes, for RFSO**	**Yes**	**Yes**	**Yes**
Recognizing Abnormal Conditions	**NN**	**Yes, for RFSO**	**Yes**	**Yes**	**Yes**
Sources of Additional Information	**NN**	**Yes, for RFSO**	**Yes**	**Yes**	**Yes**

Program Review

	I	II	III	IV	V
Adequacy of Present Program Design	**NN**	**Yes**	**Yes**	**Yes**	**Yes**
Implementation (Program in use?)	**NN**	**Yes**	**Yes**	**Yes**	**Yes**

Examples of the RF Safety Program Elements

Core Program Elements

- Administrative
- Identification of Potential Hazards
- Controls
  - Engineering
  - Administrative
  - Personal Protective Equipment
- Training
- Program Review

Administrative

- Policy
  - Management Commitment
  - Authority to enforce rules
- Accountable Persons
  - Assignment of Duties
- Documentation
- Employee Involvement
- RF Safety Committee
- Procurement of RF Source Equipment

Identification of Potential Hazards

- Inventory of RF Sources
- Exposure Assessment
  - To establish exposure categories.
  - To ensure controls are functioning.

Hazard Assessment Options

- Direct Measurement
- Indirect “Measurement” by comparing to similar sites.
- Model calculations

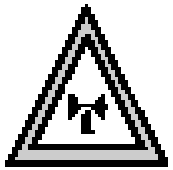
Direct Measurement

From Ric Tell

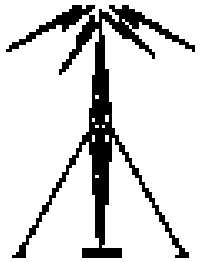
PPE and Direct Measurement

Federal Communications Commission
Office of Engineering & Technology

Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields



Additional Information for Radio and Television Broadcast Stations



Supplement A
(Edition 97-01)
to
OET Bulletin 65 (*Edition 97-01*)

Assess by modeling.

Assess by comparison.

For example, cellulars are well characterized.

(See examples at end)

Controls/Engineering

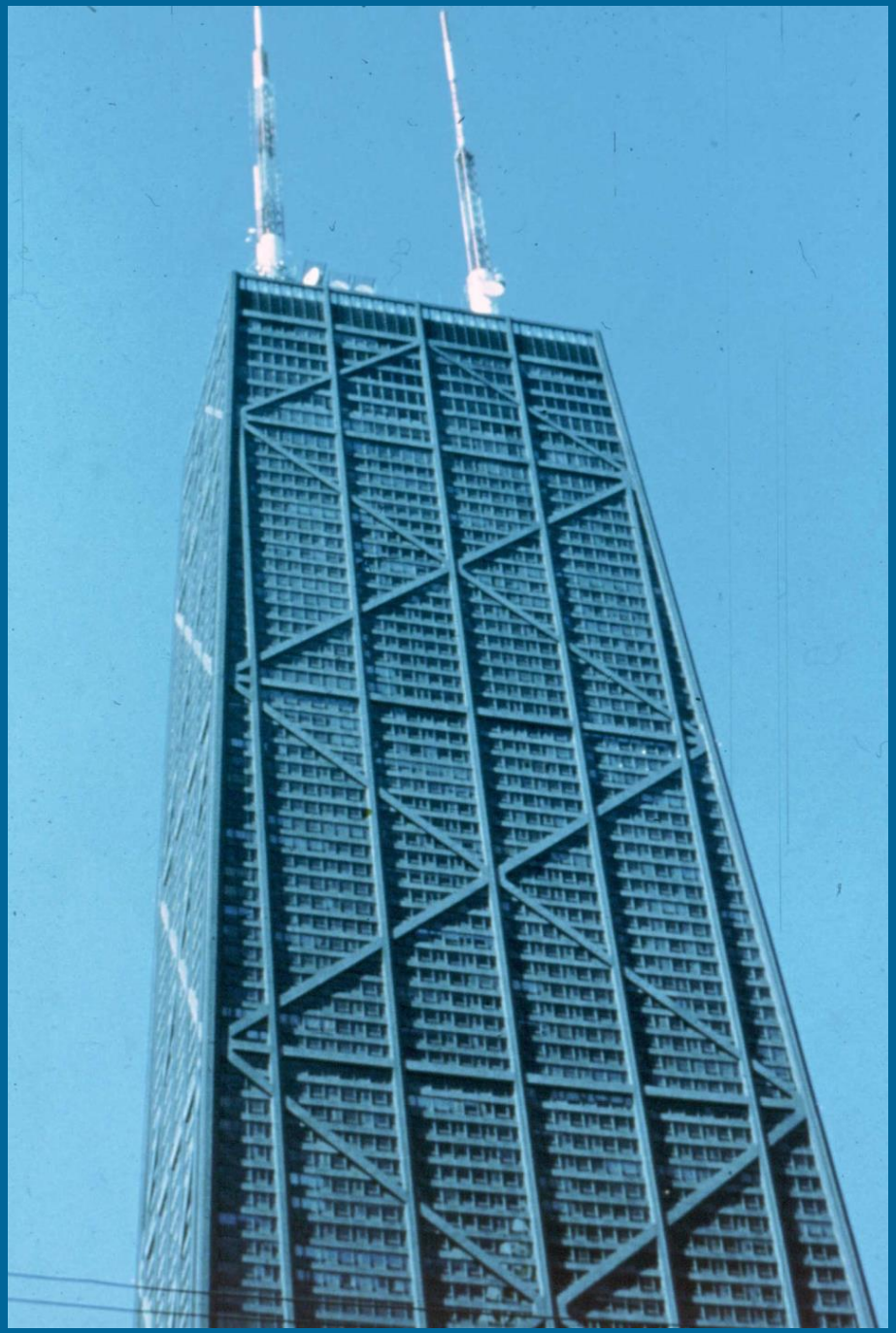
- Utilize low exposure equipment & site configuration
  - Use good equipment
  - Control hazard areas
  - Limit exposures
- Access Restriction
- Maintenance of Controls

Controls/Administrative

- Use of Signs
- Access Restriction
- Work Practices
- Control of Power Source (LOTO)
- Personal Monitors
- Incident Response
- Medical Devices and Implants
- Maintenance of Controls

Slides of Example Controls

- Lockout/Tagout
- Personal alarm
- Prevent access to hazardous locations (Signs & Fences)
- Administrative control program
- Protective clothing

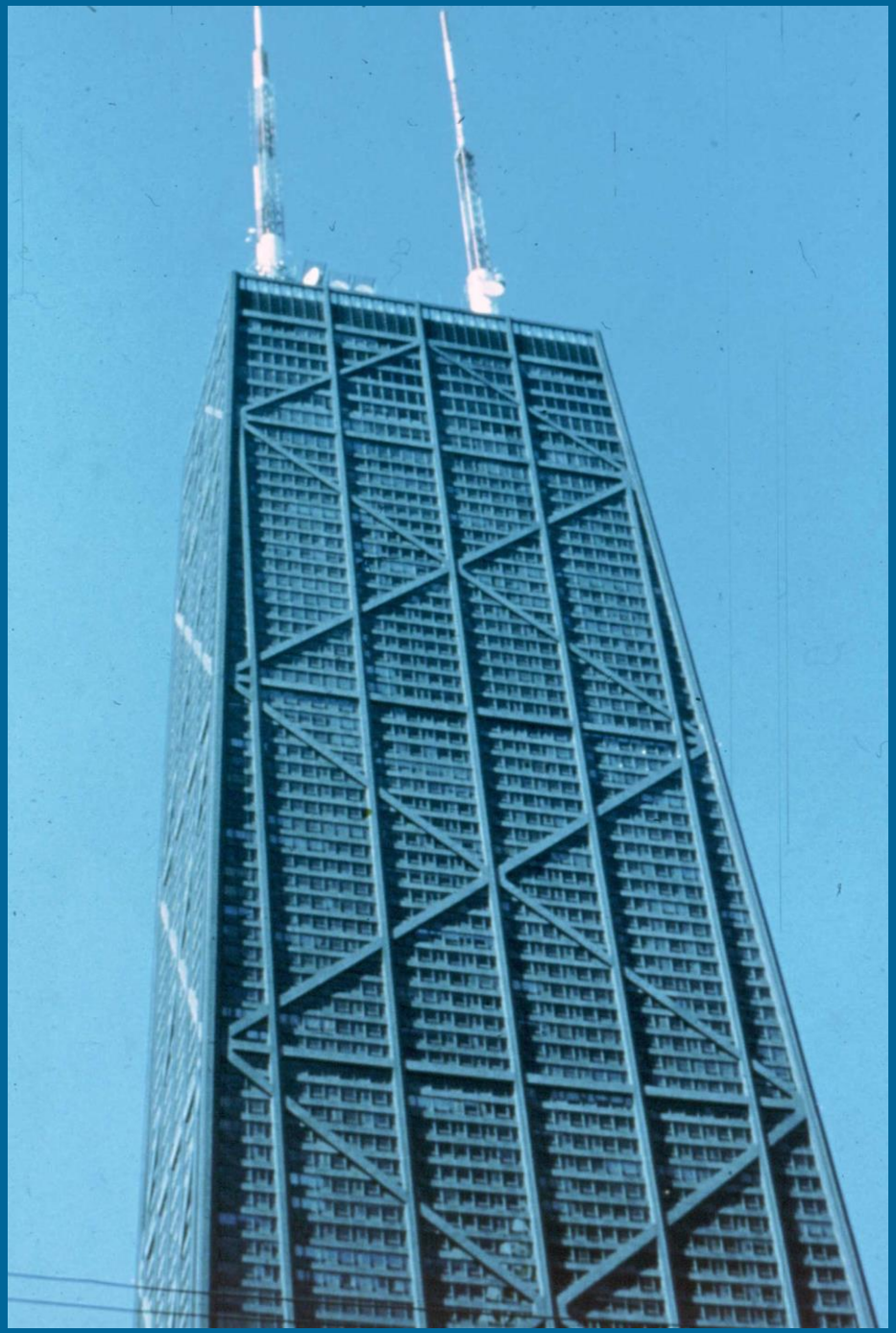


Lock Out / Tag Out

Lock Out / Tag Out Offers Protection for Workers on Tower

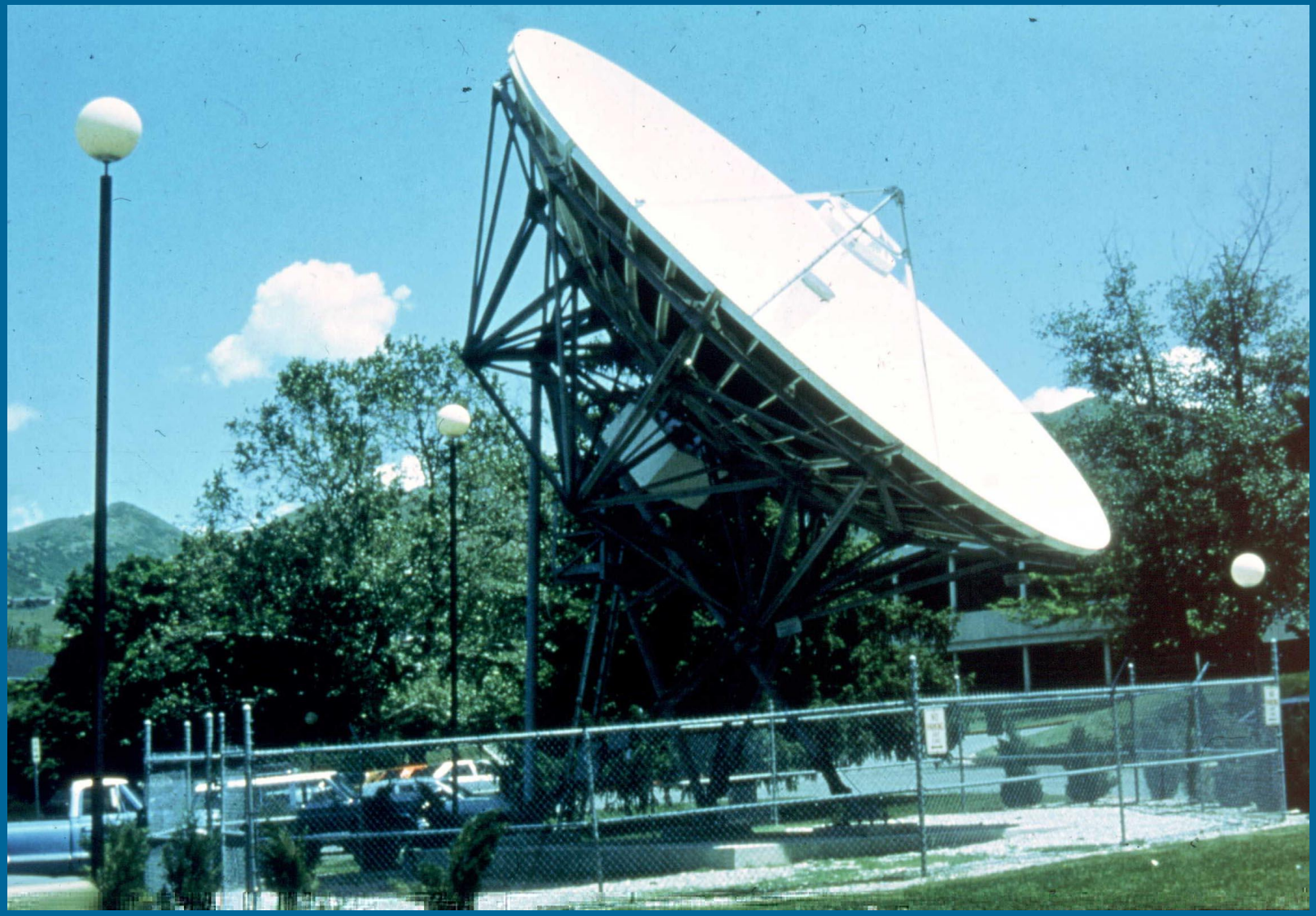
Personal Alarm

Cooperative RF Program for Shared Tower



Cooperative RF Program for Multiple Broadcasters

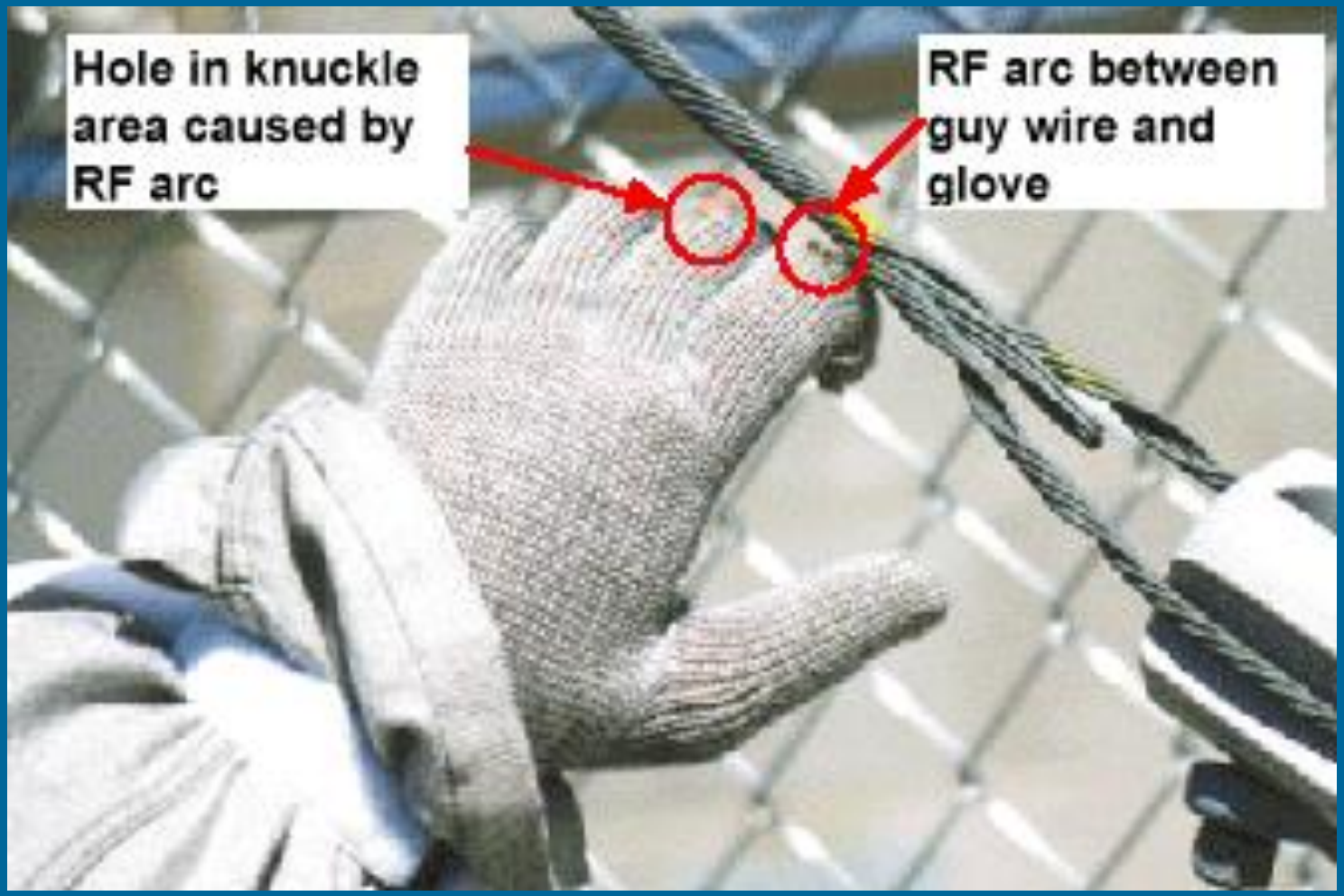
Fence to Limit Access



RF Protective Suits

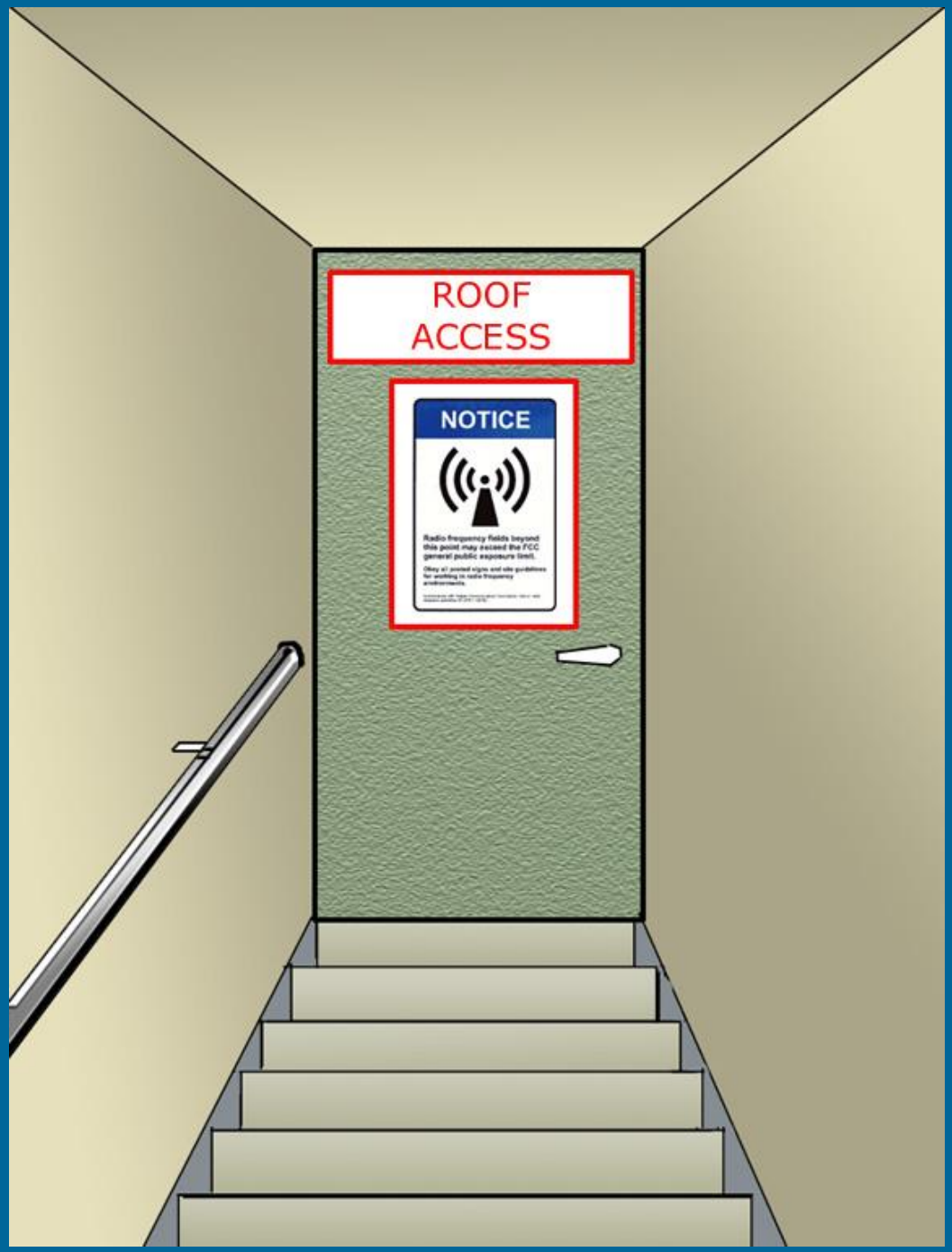
PPE Must Be Tested for Application

PPE Must Be Inspected & Maintained



From Ric Tell

Example Application of Signs Based on Exposure Category



Sign at entrance to next exposure Category.

Notice for Public required by FCC.

Sign posted at boundary between Category I & II.

Optional

Notice of Worker-based RF Control Program.

Posted at access points into Category III.

Caution workers to use Controls

Posted at access points into Category IV locations.

Alert to objects which may cause RF shock if contacted without PPE.

Alert to objects which will cause RF Burns if contacted without PPE

Posted to mark prohibited access into Category V without power-down or PPE.

Note: Wrong symbol.

Posted to mark prohibited access without power-down.

PPE is not sufficient.

Alert to objects which will cause severe RF Burns if contacted.

PPE may not be sufficient.

RF Personal Protective Equipment

- If PPE is utilized, a PPE Program must ensure its effectiveness, including proper:
  - Selection of RF PPE within tested capabilities.
  - Accessibility, Use, & Maintenance.

Training: What to Teach

- Location of sources and potentially hazardous areas.
- Health effects and safety standards.
- Extent of exposures compared to standards and common sources.
- Required SOP's and controls.
- Emergency procedures.
- How to know when things are "abnormal".
- Optional controls employees may use.

Program Review

- Adequacy of Program Design
- Program Implementation
  - Interview employees
    - What are the hazards and controls?
    - What steps have been taken to enforce the rules?
  - Determine what to change, add, and delete.

Possible Non-Mandatory Appendices

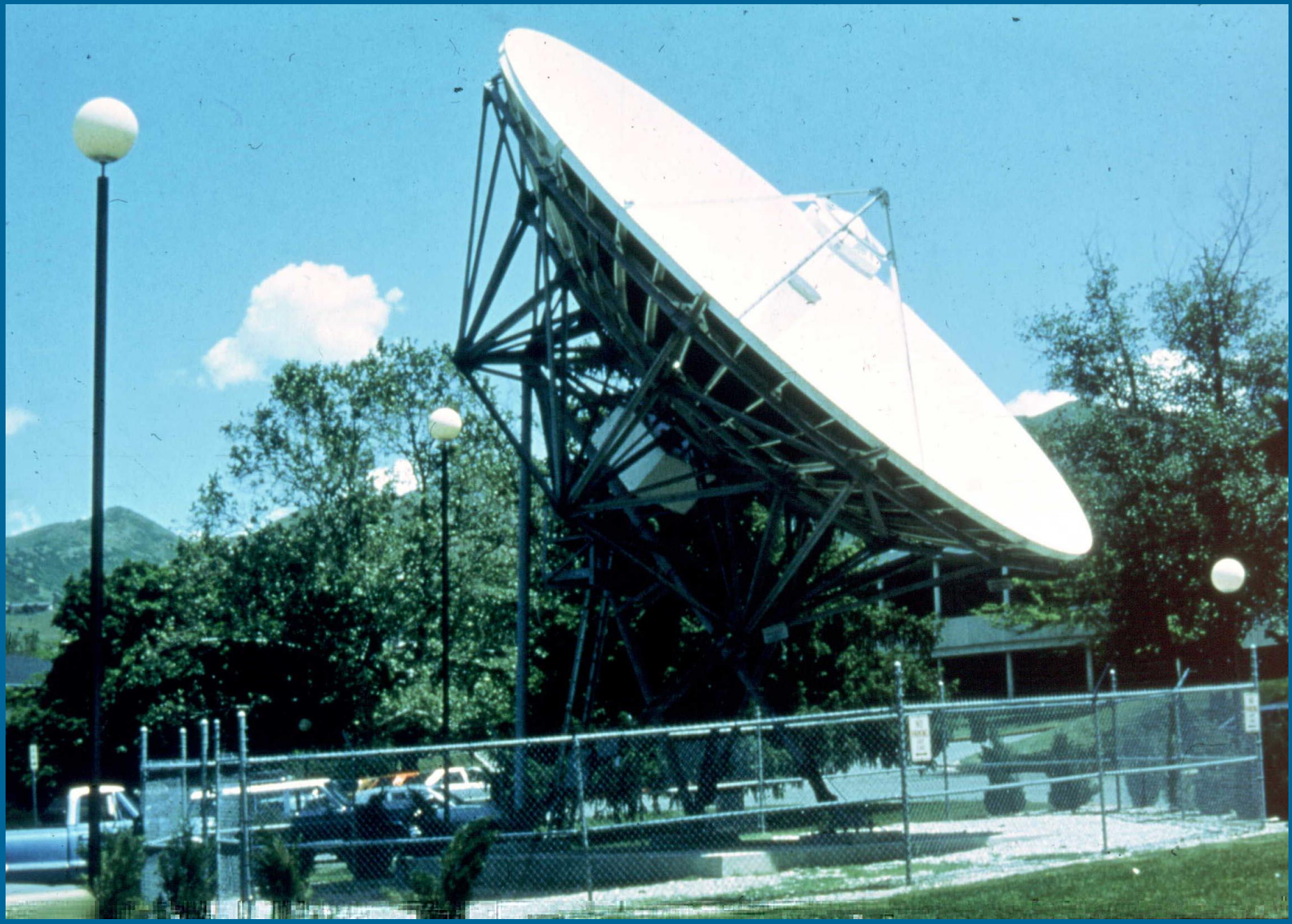
- Example RF Safety Program for a communications company which routinely services/installs antennas on rooftops.
- Appendices concerning PPE and signage

Example Applications

Category I Locations

- Most people, including workers, are in Category I locations.
- Therefore, most locations do not need an RF Safety Program.

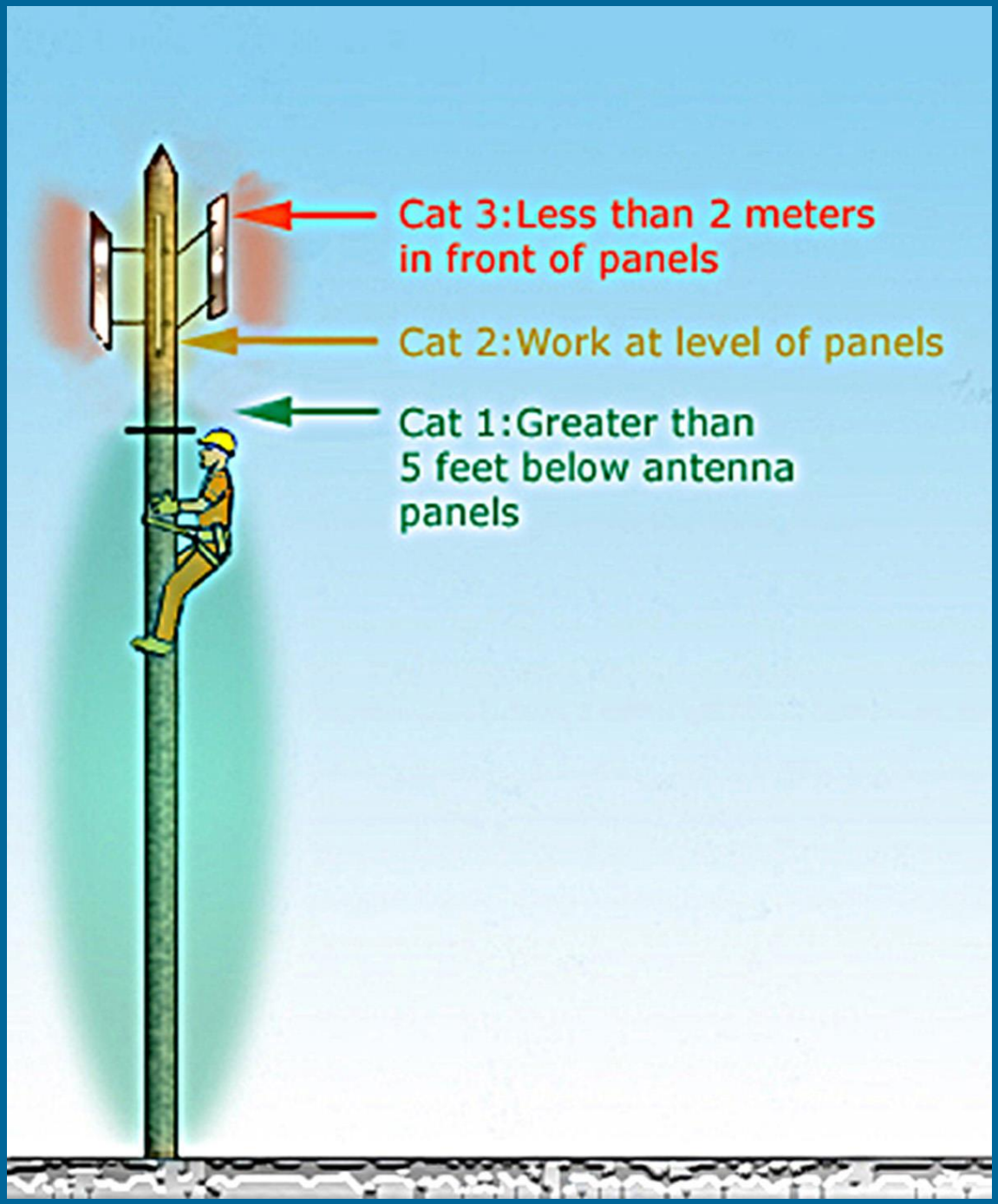
Computer Work Station

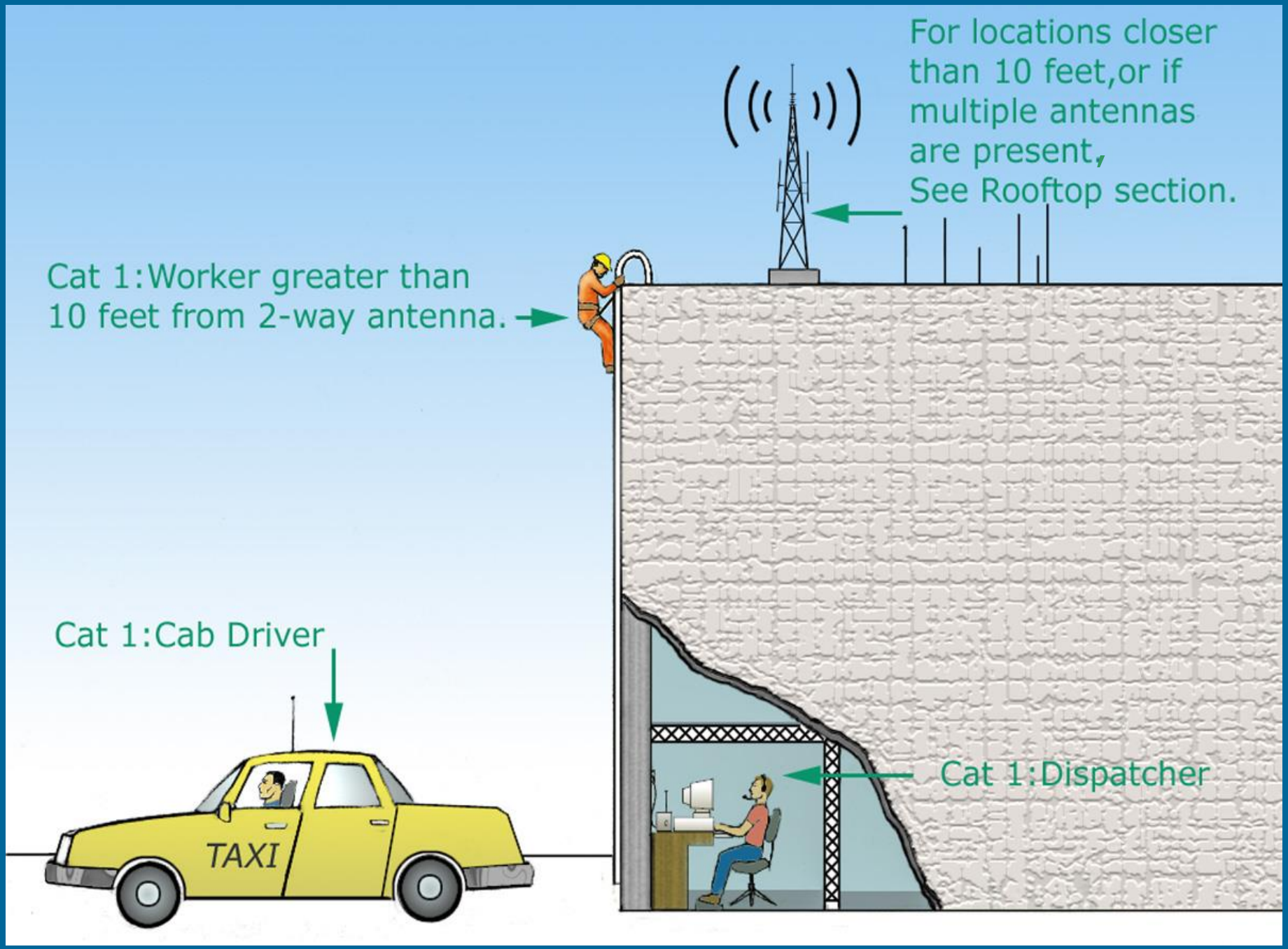


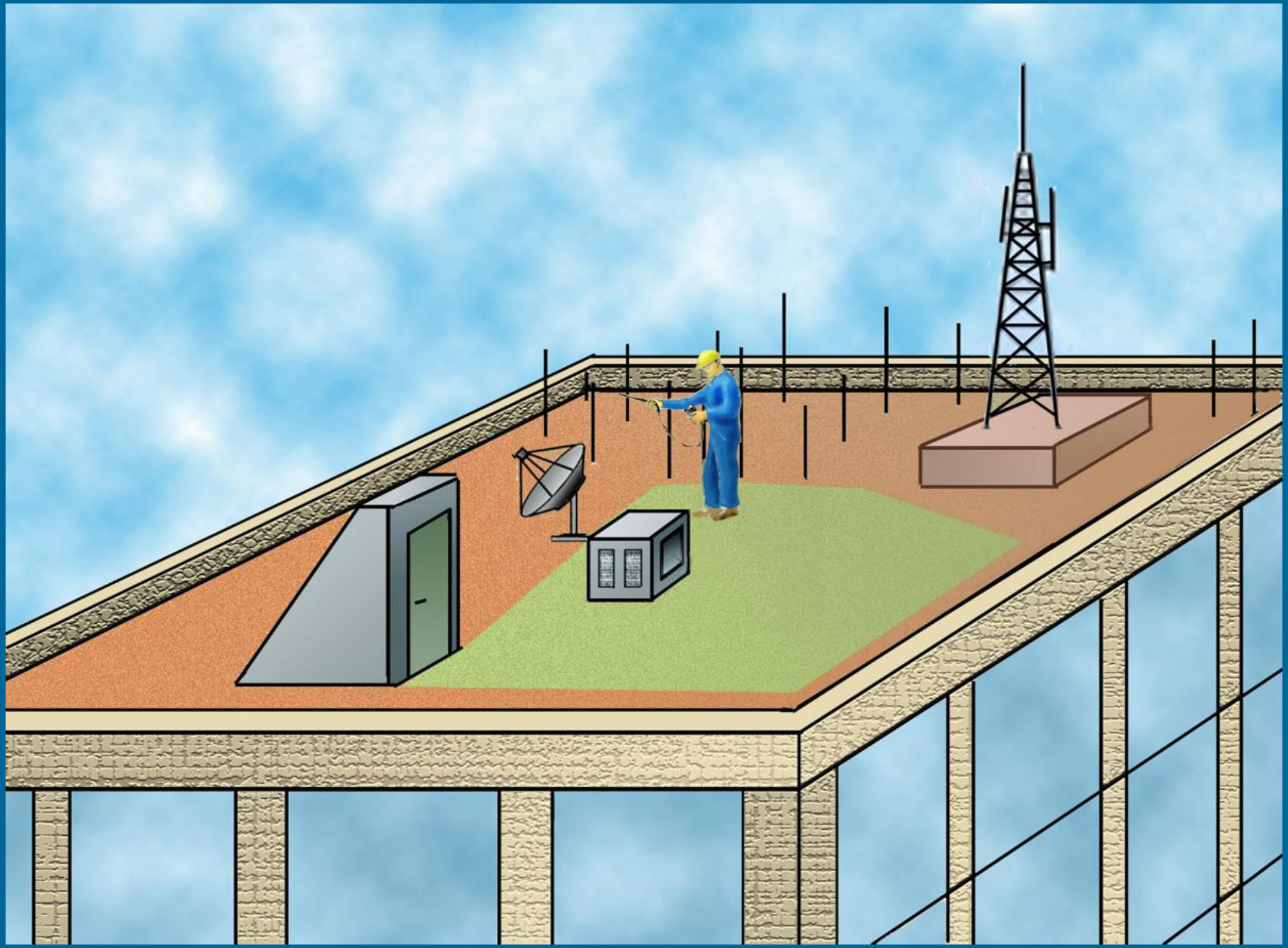
Exposure Locations

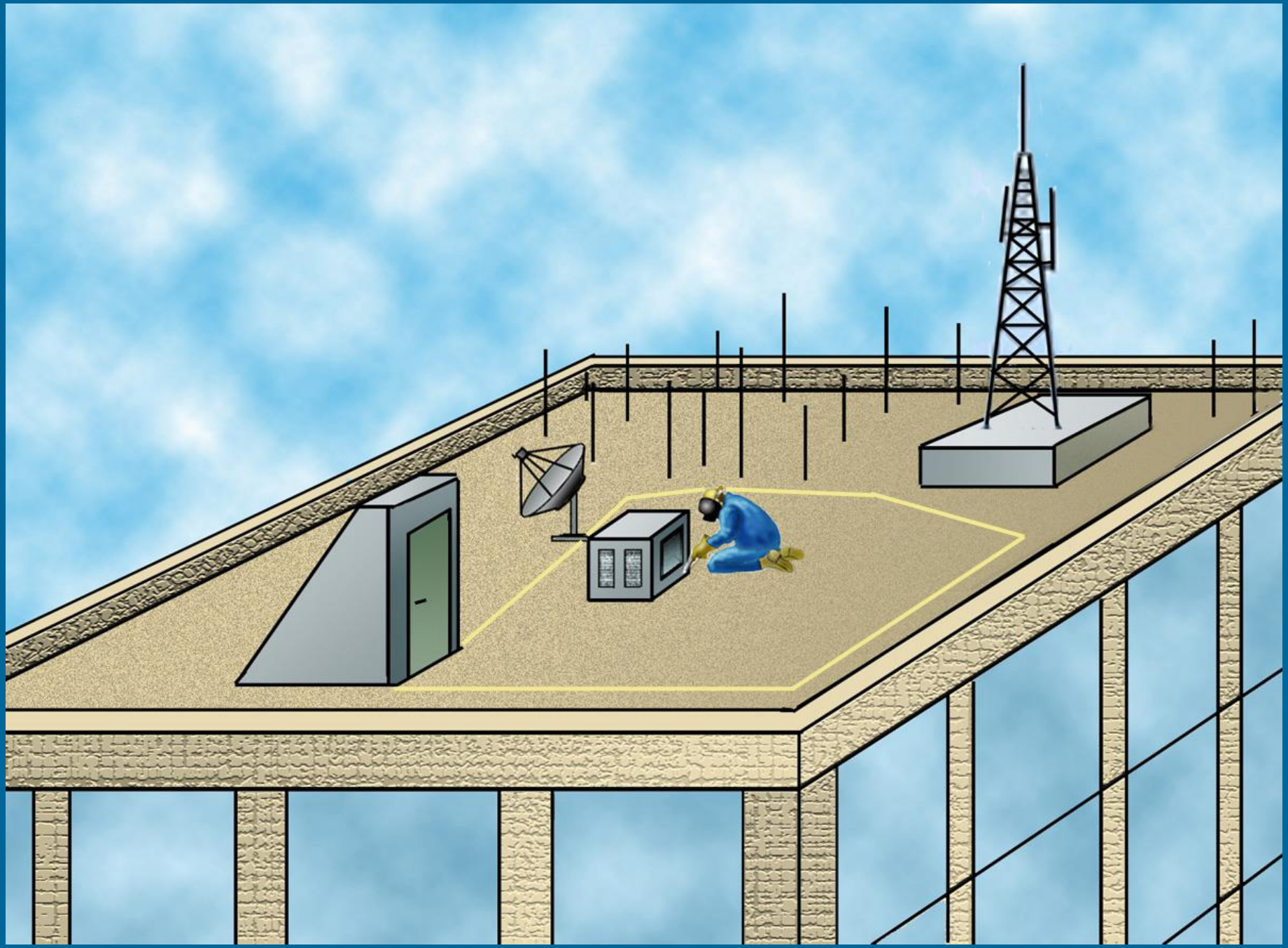
I	Outside the fence
II	Inside fence
III	On satellite dish
IV	Between emitter and focal point
V	Broken wave guide

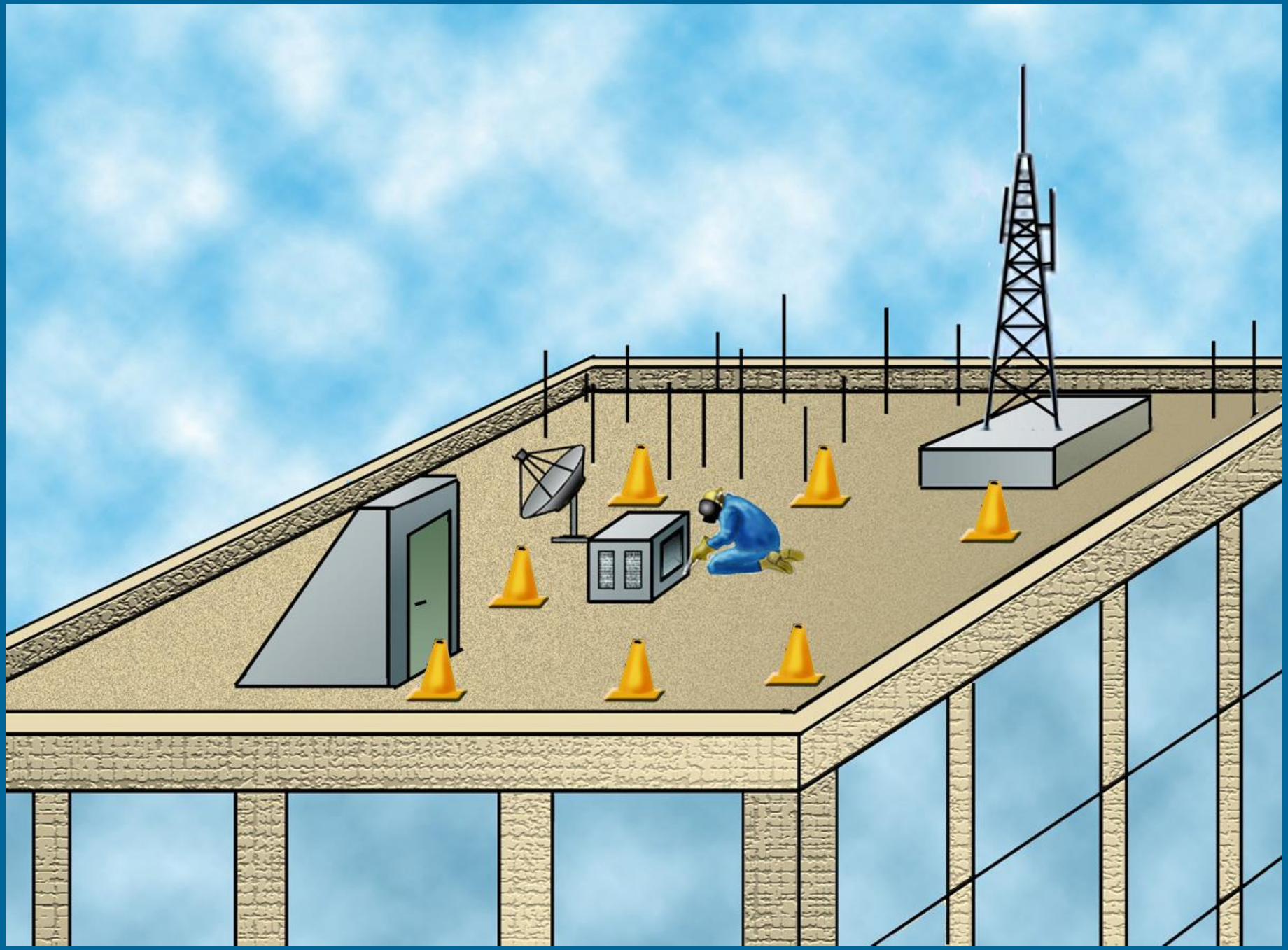
Cell Tower


Cat 3:Less than 2 meters in front of panels
Cat 2:Work at level of panels
Cat 1:Greater than 5 feet below antenna panels


For locations closer than 10 feet,or if multiple antennas are present,
See Rooftop section.
Cat 1:Worker greater than 10 feet from 2-way antenna.
Cat 1:Cab Driver
TAXI
Cat 1:Dispatcher







Safety and Health Program Core Elements

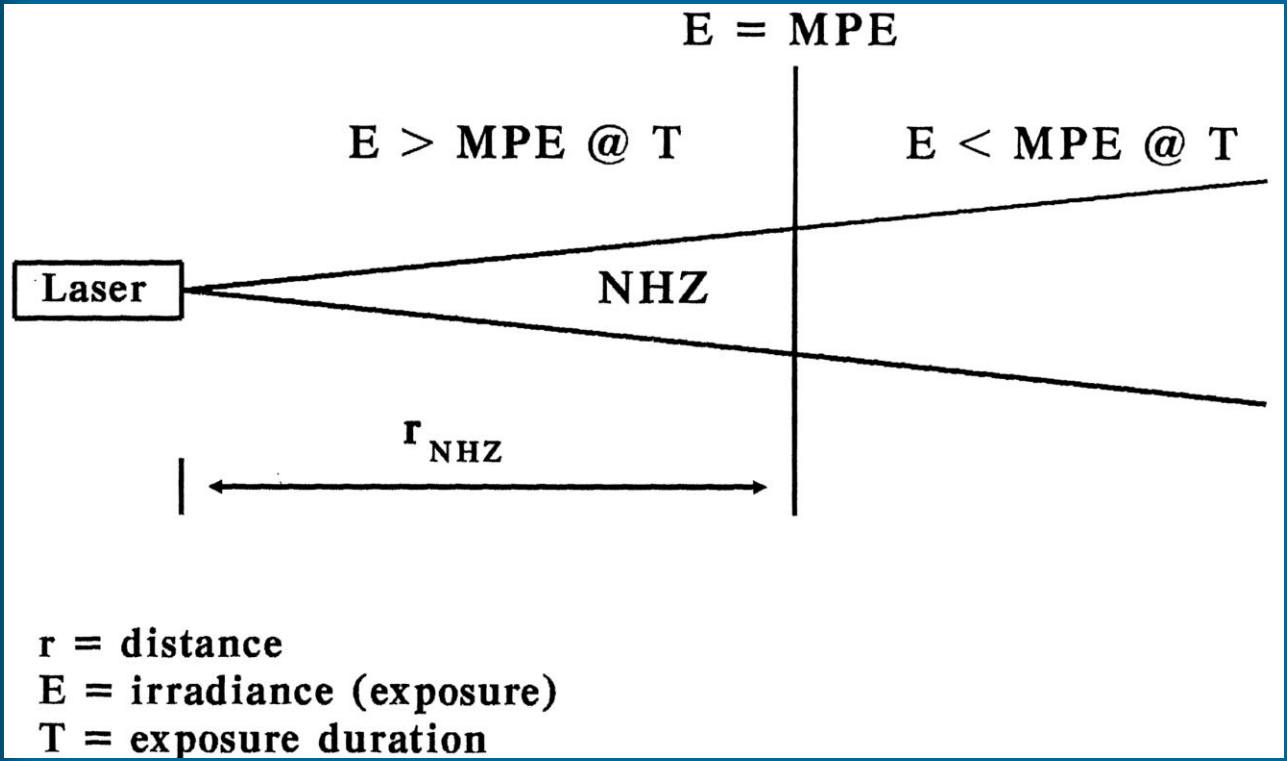
- Management leadership and employee participation
- Hazard identification and assessment
- Hazard prevention and control
- Information and training
- Evaluation of program effectiveness

Exposure While Installing New Antenna

Laser Exposure Limits - Terms

- **MPE (Maximum Permissible Exposure)**
  - the highest laser energy to which the eye or skin can be exposed for a given laser
- **NHZ (Nominal Hazard Zone)**
  - area within which the MPE is equalled or exceeded
- **NOHD (Nominal Ocular Hazard Distance)**
  - distance along the laser beam axis beyond which is acceptable for eye exposure

Nominal Hazard Zone



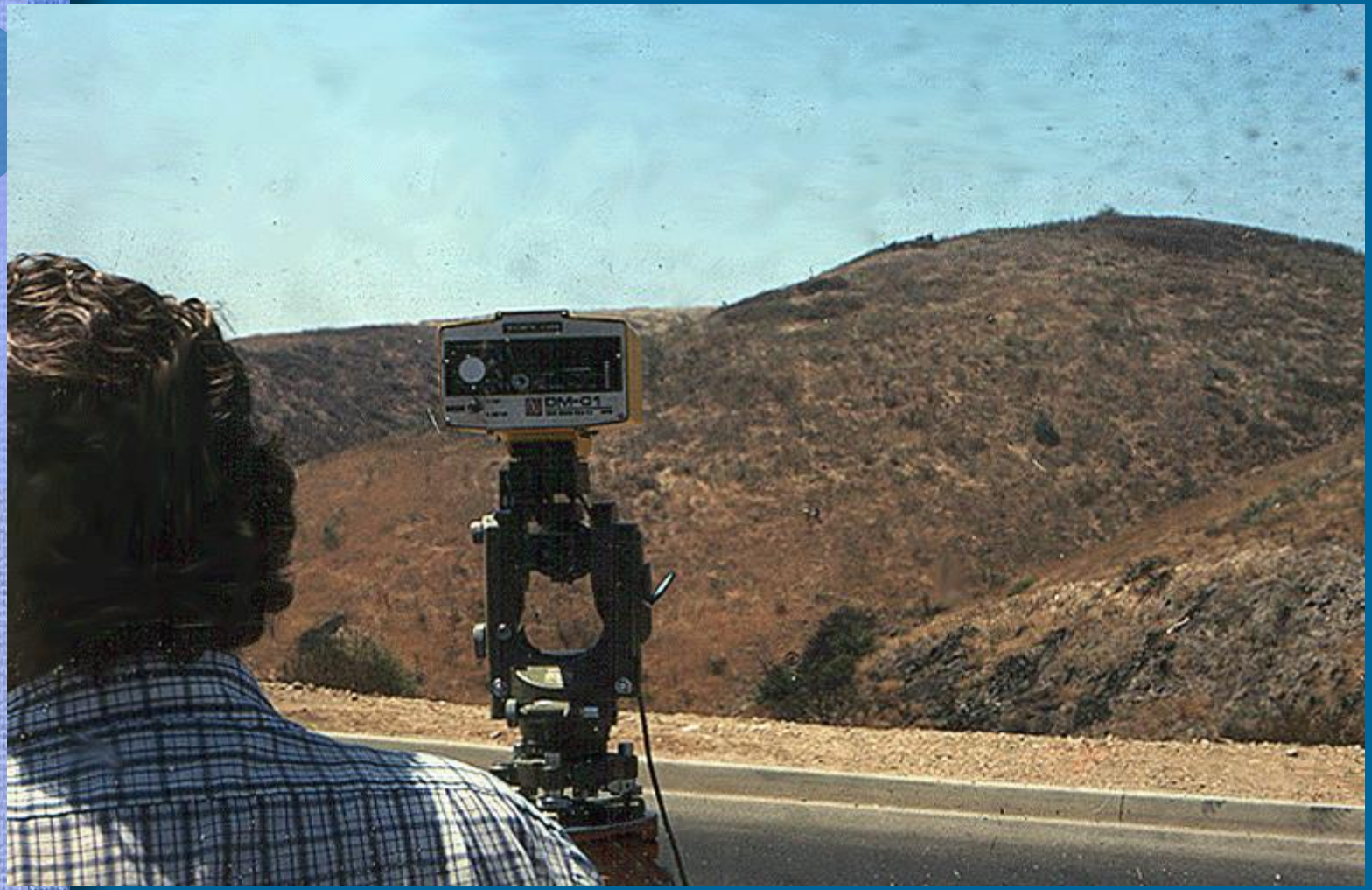

DM-01

TABLE 28-7

Minimum Optical Densities Required of Protective Eyewear

($OD_{min} = \log_{10} H_o/MPE$ or $\log_{10} E_o/MPE$)

E_o/MPE or H_o/MPE	OD_{min}
$1 = 10^0$	0
$10 = 10^1$	1
$100 = 10^2$	2
$1000 = 10^3$	3
$10000 = 10^4$	4
$100000 = 10^5$	5
$1000000 = 10^6$	6

Where H_o is equal to the emergent beam radiant exposure in Joules per square centimeter and E_o is equal to the emergent beam irradiance in Watts per square centimeter.