RFI SHIELDING

CONTENTS PAGE

Figures PAGE

Tables

1. GENERAL

1.01 This section discusses and provides standards for RFI Shielding. These standards are provided for use in the design of new buildings or building additions that are intended to house telephone equipment that meets the requirements of Bell System Practice 800-610-164, "New Equipment-Building System (NEBS), General Equipment Requirements."

1.02 This practice supersedes Section 8.2 of Specification X-74300, "NEBS Building Engineering Standards (BES). This section is reissued to correct Fig. 2. Change arrows are used to denote information added to the section.

DESCRIPTION

1.03 Electromagnetic fields can cause interference in electronic communication systems. These fields may have frequencies from 25 Hz up to tens

© American Telephone and Telegraph Company, 1978
Printed in U.S.A.

of GHz, and no location is entirely free from their effects. Among the many sources of electromagnetic interference, the two most common are the 60-Hz power network and licensed radio transmitters, including radars (both fixed and mobile). Other sources include electric railway lines and certain types of industrial, scientific, and medical equipment (such as induction heaters and diathermy machines). Some unusual sources occasionally are discovered, such as the multimegavolt artifical-lightning machine at a test laboratory adjacent to a proposed wire-center site.

SCOPE

1.04 While it is usually economically possible to reduce the levels of electromagnetic radiation within a Central Office building sufficiently to eliminate interference with equipment operation, it is generally less expensive and more satisfactory to check the location for potentially troublesome fields before the site is purchased and building construction is begun. If any such fields are found, it may be possible to choose a less susceptible location for the building.

1.05 Electromagnetic interference (EMI) caused by the power network is usually of low frequency (60 Hz) and harmonics except for some RF noise generated by corona or spark discharges. The probability of interference from the power network is highest near installations such as high-tension lines and substations. These installations should be avoided when a site for a Central Office building is being chosen.* On the other hand, radio-frequency interference (RFI) is more pervasive, and its sources are sometimes less obvious. In minimizing equipment disturbances caused by RFI, choosing the building location to avoid proximity to strong RFI sources is still the best solution, but the shielding that can be provided by the telephone building is also important.

*Further information on protection against power-frequency interference may be found in Section 760-220-130.

1.06 This section discusses sources of electromagnetic interference, and gives the currently allowable limits for 60-Hz and RF fields for No. 1 ESS equipment. Pending further investigation, these limits can be assumed to apply to all ESS equipment (including No. 2, No. 3, and No. 4). Various building shielding systems are described, and RFI shielding values for some typical Central Office buildings are presented for frequencies ranging from 18 kHz to approximately 100 MHz. Note that the limits are stated for certain susceptible bays of the ESS offices. While no quantitative data are presently available, some self-shielding may be provided by surrounding equipment bays. ➧Prudent design practice calls for placing the most susceptible bays well back from the outside walls of the building.➧

1.07 The shielding methods and techniques described are applicable primarily to RFI at frequencies below 100 MHz. Above this frequency, shielding becomes increasingly more expensive and more difficult to engineer.

2. ESTIMATING RFI

2.01 Radio frequency interference usually originates from nearby industrial, scientific, or medical apparatus, or from radio, television, or radar transmitters. The two types of radar most likely to produce strong fields in a Central Office building are aircraft surveillance radars and weather radars. Normal operation of these high-power radars includes scanning at antenna angles low enough that the main beam of the radar could at times be pointed directly at the telephone building. Planning for any new Central Office Building, particularly one to be located near an airport, should include a survey for such radars. Any other obvious sources of RFI should also be avoided. However, since it is seldom possible to find a location that is completely free from sources of RFI, a basic procedure should be followed to determine the RF field in the proposed location, prior to purchase, if a problem is anticipated, and to ascertain whether or not the field is likely to cause disturbance to the equipment or cause economic penalities.

2.02 The outline of such a procedure is shown in Fig. 1. Basically, the RF ambient field strength at the proposed building location is estimated by calculation or measured with instruments, the amount of RF shielding provided by the proposed building is determined, and the resultant RF fields inside the building are then compared with acceptable levels. If the acceptable levels are not exceeded, construction can proceed. However, if calculations reveal that an excessive level of RFI would be present in the building, a decision must be made as to the relative merits of finding another site, altering the type of building to one giving more shielding, or adding shielding material to the existing building design. Once a satisfactory solution has been found and the building has been completed—but before any equipment is installed—RFI measurements must be made to ensure that the RFI levels inside the building are within allowable levels.

3. RF FIELD-STRENGTH MEASUREMENTS

3.01 When RFI problems are suspected, measurements are necessary to determine the RF field strength at a proposed building site,* to evaluate the shielding qualities of a particular class of building, or to ensure that RFI levels inside a completed building are sufficiently low. The Building Engineer may request the Transmission Engineer's office to supply field strength and shielding estimates and/or to make necessary measurements. Alternatively, this work may be contracted to an outside consultant.

*At proposed building sites where RFI might alter the economics of the building, it may be beneficial to make prior testing and acceptance of the site a contingency of the land acceptance agreement.

3.02 Detailed information on identifying and estimating sources of RFI and on RFI measurement method is contained in Section 760-850-101, RFI Shielding Test Procedures. This practice provides the necessary guidance for the measurement of electromagnetic radiation fields at a proposed site of a new building and in an existing telephone building to determine whether field strengths from existing licensed radio transmitters are of troublesome magnitude. These procedures permit the determination of the shielding effectiveness of an existing telephone building or type of construction.

3.03 In determining the degree of shielding provided by an existing building, it is often possible to use local radio stations (including AM, FM, weather, and navigation control stations) as sources for the incident RF fields. Because of the economic, legal (licensing), and manpower problems involved, the setting up of a transmitter to provide a locally generated field solely for shielding measurements is not advised, even though the data so obtained would fill in large gaps of the frequency spectrum. If it is absolutely necessary to do this, the services of one of the large electromagnetic consulting engineering firms should be hired to perform the complete task, as it probably lies within their experience.

4. MAXIMUM ALLOWABLE FIELD STRENGTHS FOR ESS EQUIPMENT

4.01 Tests have been conducted at Bell Laboratories to determine the maximum (peak) levels of electromagnetic radiation that can be tolerated by the components of a No. 1 ESS. ➧The power of Fig. 2 is the effective radiated power in the direction of interest.➧ Based on the results of these tests, upper limits have been set for the levels of 60-Hz, RF, and microwave radiation to which these components may safely be exposed. These component values have been used as safe limits for the entire No. 1 ESS. They are considered representative for all ESS equipment, pending further tests.

4.02 The curves of Fig. 2, which are based on data of Table A, show the relationship between the power of an RF source and the permissible distance from it to an ESS office. In the region to the left of each curve, the combination of distance and power requires that measurements be made to determine whether the building needs shielding to avoid exposing the equipment to a level of RF radiation beyond the recommended maximum. Of course, the final decision as to whether shielding will be needed must also include such factors as multiple sources and possible increases in the power of the source over the life of the telephone building.

4.03 There is a region close to an RF signal source where the calculation of field strengths is mathematically complex due to near-field phenomena. Because the magnetic components of the radiation field are large and may be troublesome in this near-field zone defined by the wavelength of the source divided by 2π, construction of an equipment building within the zone should be avoided.

5. CENTRAL OFFICE SHIELDING METHODS

5.01 There are three basic ways to provide RFI shielding for Central Office buildings.

(a) To provide shielding integral with the building structure.

(b) To apply separate shielding during or after construction.

(c) To construct special shielded rooms within the building.

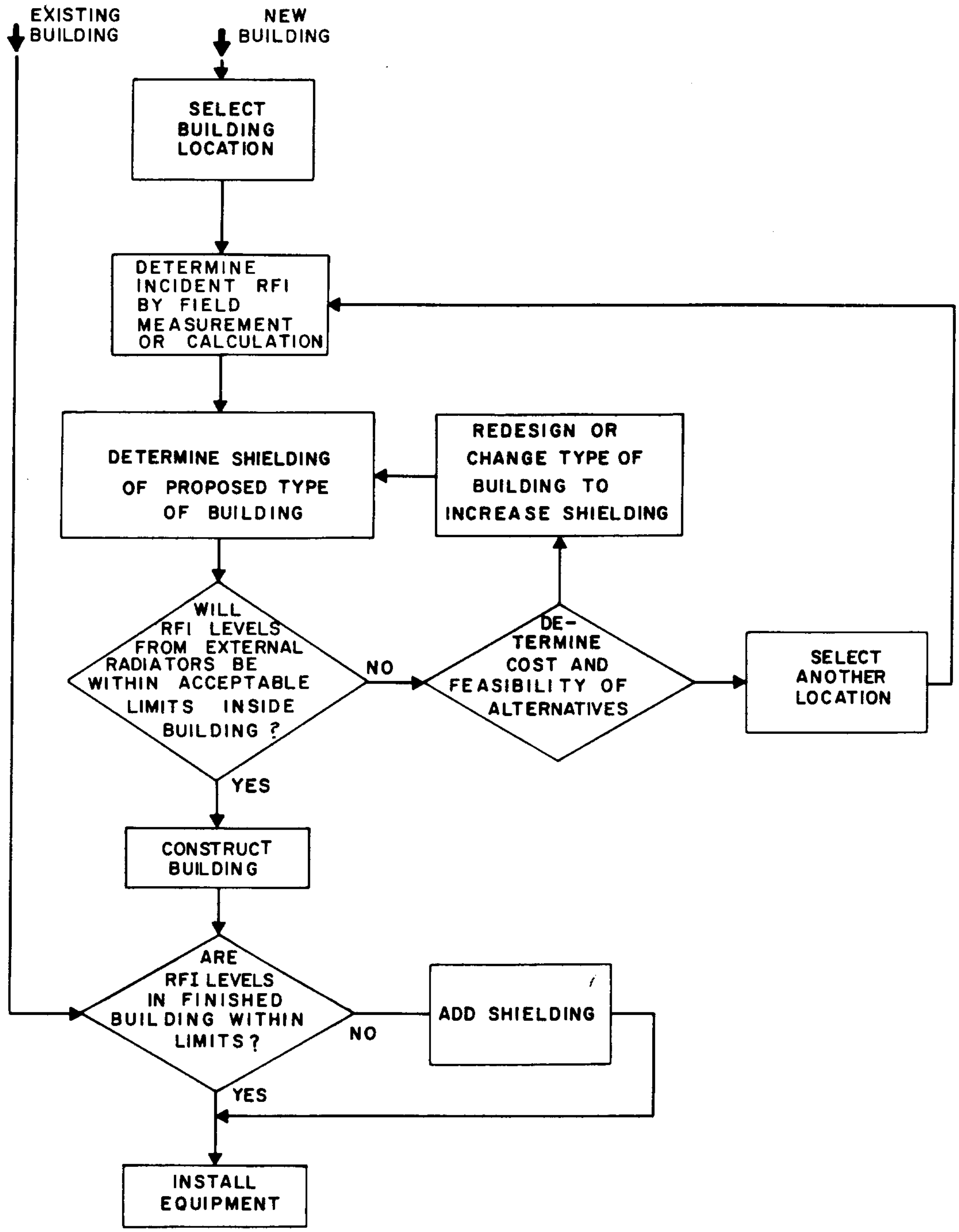


Fig. 1—Basic Procedure For Minimizing Potential RFI Problems

TABLE A

MAXIMUM ALLOWABLE FIELD STRENGTHS, ESS EQUIPMENT

FIELD	AFFECTED UNIT	FIELD STRENGTH CAUSING ERRORS (GAUSS)	MAXIMUM ALLOWABLE FIELD STRENGTH (GAUSS)
Power frequency (60 Hz)	Call store	25	8
	Permanent-magnet twistor store	35	8
	Magnetic card writer	0.3	0.1
RF (10 kHz to 1 GHz)		Maximum allowable field strength (dB above $1\mu V$/meter)	
	Program store	127 (approx 2 volts/meter)	
Microwave radar (peak power above 1 GHz)	Call store	141 (approx 10 volts/meter)	

A. INTEGRAL SHIELDING

5.02 This type of shielding has the advantage that it can usually be implemented with a small, if not negligible, increase in building cost. The general approach is to use as shielding some of the materials that are normally provided in the structure of the building. In concrete buildings, the steel reinforcement can, in many cases, be detailed to serve as the shielding material.

5.03 In precast concrete buildings, the wall panels can be constructed with galvanized wire mesh embedded in the concrete to provide shielding as well as to enhance the strength of the panels. This mesh is typically some kind of welded wire fabric, and makes an effective shield against RFI at frequencies below 100 MHz. The ends of the wire mesh project out from the edges of each panel, and the ends from adjacent panels are bonded electrically at frequent spacing to form the wall shielding. The mesh at the top and bottom of each panel is similarly brought out, and is bonded to the shielding mesh in the concrete floor slab and in the roof. Metal window and door frames are bonded to the mesh. Precast concrete construction is particularly good for telephone company buildings because of the relative speed with which the building can be completed, and because of the small increment of cost required to provide a range of effective shields. The size of the mesh and the spacing of bonding points between sections of mesh determines the highest frequency against which the shielding will be effective.

5.04 Another method of integral shielding utilizes the forming for the reinforced concrete slab for both the reinforcing and the shielding material. When a concrete deck is poured over a structural steel frame building, some type of corrugated steel decking is used to span between steel beams and act as forming when the concrete is placed. Bonding of adjacent pieces of decking and protection of penetrations is accomplished in a manner similar to the mesh situation. If reinforced concrete is used without metal decking, a large wire mesh (6 inches by 6 inches minimum) can be tied to heavier reinforcement and cast in the floor, roof, or wall.

B. SEPARATELY APPLIED SHIELDING

5.05 This type of shielding is independent of the construction of the building. The shielding material is applied as a completely separate system

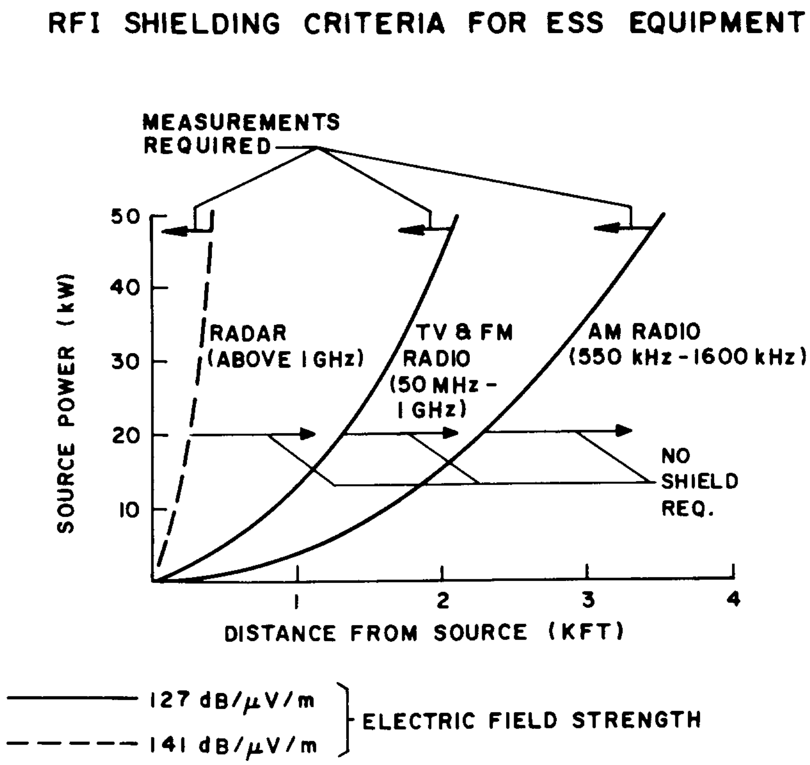


Fig. 2—Relationship of RFI Source Power and Distance to Maximum Permissible Field Strengths For ESS Equipment

during construction or after the building is completed. Therefore, this type of shielding is particularly suited for block-wall or brick-and-block-wall construction. It may also be useful when only certain stories or areas of a building require shielding. The conductive shield may be between any pair of the layers of the wall material or on the extreme inside of the building. In general, separately applied systems cost more than integral systems, because the entire cost of the shielding material must be considered as an add-on, although the cost depends to an extent on the type of building construction.

5.06 Conductive paints and wallpapers fall into the separately applied category, but at present no recommendation of these materials can be given, pending further investigation of the effectiveness and long-term reliability.

5.07 Separately applied shields also include sheet metal or screen mesh. With these, in addition to the cost of the materials, there is the expense of providing a seam between adjacent sheets. However, shields made of sheet metal or wire mesh (with a grid spacing of 1/4-inch or less) currently appear to be the most effective against fields in the 500-MHz frequency range.

C. INDIVIDUALLY SHIELDED ROOMS

5.08 This type of shielding is not proposed for broad use in the Bell System. It may, however, be useful in certain special applications. It involves the construction of individually shielded rooms or compartments within the building. These enclosures are commercially available as complete systems to shield small portions of larger buildings. Their expense is due mainly to the room-within-a-room concept and the associated redundancy in materials and labor.

6. BONDING, PENETRATIONS AND OPENINGS, AND GROUNDINGS

6.01 The success of protective shielding lies not only in the choice of material, but also in the attention given to design details and in the quality of workmanship. Three areas in particular require close attention: bonding, treatment of penetrations and openings, and grounding.

A. BONDING

6.02 Bonding refers to the electrical connection between adjacent segments of the building shield. This must be done so that the long-term effectiveness of the bond will not be impaired by corrosion, by settling, by vibration, or, future alteration. The quality of the bond between adjacent sections of shielding often is the most important factor in determining the shielding performance of a building.

6.03 Seams in sheet metal shielding may be of two types: pressure or welded. The effectiveness of pressure seams depends on the magnitude and uniformity of pressure applied to the seam and the electrical cleanliness of the mating surfaces. Pressure-seam construction may deteriorate as a result of eventual relaxing of the shield material. Good-quality welding is a more reliable means of obtaining satisfactory, nondeteriorating seams.

6.04 It is more important that every strip of mesh shielding be bonded electrically to the next strip at least every 12 inches, and that this bonding include all wall-to-wall, wall-to-floor, and wall-to-ceiling mating edges. Bonding at 12-inch intervals is suitable for frequencies up to 100 MHz, but higher frequencies would require closer spacing of bonding points. Crimp connectors are recommended, as is soldering or spot welding of the joints, provided that the materials used will not corrode the bond. All strips of mesh should overlap a minimum of 2 inches where they are bonded.

B. PENETRATIONS AND OPENINGS

6.05 Penetrations are any structures, such as cables or pipes, that may carry RFI into a shielded building. Any such penetration of the shield should have its sheath or perimeter bonded by a short connection to a metal plate at the point of entry into the building. The metal plate should, in turn, be bonded to the building shielding by connections around the periphery of the plate. These connections should be short, direct, and of low inductance to avoid radiation into the building by currents on the cable sheath or on the wires that connect the sheath to the building shield. Any wire entering the shielded area should be properly filtered to prevent coupling of undesirable radiation into or out from the shielded area.

6.06 The frames of openings, such as doors, windows, or louvers should be bonded to the adjacent building shielding at least once on each side, preferably every 12 inches. Telephone and power cables entering the building should travel underground for 100 feet or more before entering the cable vault or power room. Air plugs should be inside within 10 feet of the entrance into the building, and the cable shields should then make short, direct connections to each other and to a nearby ground bus.

C. GROUNDING

6.07 The building shielding, if not already part of the structure, should be electrically bonded to the steel structual members or reinforcing structure of the building, which should, in turn, be connected to ground. One point for grounding the building shielding is at the ground bus in the cable vault, where the shields of incoming cables are grounded. Connection of the building shield to this ground bus should be by at least two short No. 8 wires. If the ground bus is near a corner of the building, it should be grounded once to the shield in each adjacent wall. Connection of the building shield to the building ground system should be done at two or three places in addition to the cable-vault ground bus.

7. RFI SHIELDING CHARACTERISTICS OF CENTRAL OFFICE BUILDINGS

7.01 The energy of electromagnetic waves is attenuated in passing through the walls of the building. The degree of attenuation depends on:

(a) The frequency of the wave

(b) The electrical properties of the barrier

(c) The thickness and density of the barrier.

7.02 At present, there is no precise way of predicting the attenuation that may be achieved for any given source strength, building geometry, or method of shielding. However, several types of equipment buildings have been tested by Bell Laboratories to determine the success with which RFI from nearby radio stations is attenuated. The results of these tests are discussed in the following paragraphs.

A. PRECAST CONCRETE BUILDINGS

7.03 A study was made of the shielding provided by two standard Illinois Bell No. 2 ESS buildings located close to several 50-kW AM broadcast stations in Chicago. These buildings in Romeoville and Frankfort, Illinois, are single-story structures of approximately 5000 square feet, with poured-in-place concrete foundations, slab-on-grade floors, precast concrete sidewall panels, prestressed concrete roof beams, and precast concrete roof slabs. Briefly, the walls in the Romeoville building are shielded in lightweight wire mesh that is cast in the panels and bonded to a copper perimeter loop around the foundation. Floor shielding consists of a metal-backed raised-floor system. Individual copper conductors in each of the roof beams provide the roof shielding. Because the Romeoville building did not provide significant shielding against low-frequency H-fields or against high frequencies, the shielding was modified for a similar building in Frankfort. In this building, the shielding in the walls, roof, and floor is provided by 0.030-inch steel wire with a 2-inch hexagonal mesh ("chicken wire"). The wire is precast into the wall panels and is brought out on the sides of each panel so that it can be bonded to the mesh in the adjacent wall panels before the space between the panels is caulked. The mesh at the top and bottom of each panel is similarly brought out and is bonded to the shielding mesh in the concrete floor slab and the roof. The test results for the Romeoville and Frankfort buildings are given in Table B, which shows the minimum shielding values for various frequencies.

7.04 Because of the success and low cost of the mesh shielding used in these buildings, it is planned that future precast-concrete Illinois Bell No. 2 ESS buildings that require shielding will use a system similar to the Frankfort building, with the following recommendations:

(a) Air-conditioning refrigerant pipes should be grounded by short, direct connections to

TABLE B

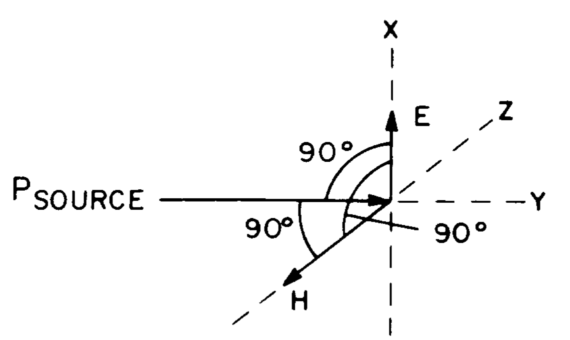
RFI SHIELDING IN PRECAST CONCRETE BUILDINGS

BUILDING LOCATION	FREQUENCY	SHIELDING (dB)	
		E-FIELD*	H-FIELD*
Romeoville, Illinois[1]	18 kHz	39	1
	890 kHz	27	7
	1 MHz	21	2
	96 MHz	-1.5	-
	18 kHz	51	-4**
	560 kHz	43	12
Frankfort, Illinois[2]	890 kHz	43	20
	1 MHz	53	21
	90 MHz	5	-
	96 MHz	10	-

1. Wire mesh in walls bonded at bottom edge only. Individual conductors in roof beams. Metal-backed raised floor.

2. Wire mesh in all six sides of building. All adjacent wall, roof, and floor panels bonded together. Mesh was inadvertently omitted from the step in the floor at the front of equipment. This produced the low-frequency magnification shown for the H-field at 18 kHz.

* The E-field (electric component) and H-field (magnetic component) are related by:



the perimeter angle directly below the points where they penetrate the wall.

(b) At least four, and preferably eight, positive electrical bonding connections should be provided between the shielding mesh and all sides of the metal frames of doors or grille vent openings.

(c) A galvanized perimeter angle should be used around the foundation to ensure a nonrusting contact between the galvanized mesh and the angle.

(d) The shielding mesh should be installed so that, where it makes the upward turn from subfloor to perimeter angle, it will be inside poured concrete to give it better protection.

(e) The mesh in each panel should be completely bonded to that in adjacent panels in the walls, roof, and floor.

7.05 Note that the Romeoville and Frankfort buildings were only spot-tested at frequencies up to 96 MHz. This is a circumstance where shielding is needed against only the lower frequency spectrum, eg, low frequency communications, AM broadcast, or medium high frequency transmissions encompassing a frequency range between 300 KHz and 30 MHz. In this case it would be uneconomical to protect against a wider frequency extension on either side of the spectrum. Without further tests, no assurance can be given about the effectiveness of shielding in the UHF-TV band or against continuous-frequency radiation outward.

B. POURED-IN-PLACE CONCRETE BUILDINGS

7.06 Investigations of RFI shielding were made on certain poured-in-place concrete buildings along the L5 coaxial cable route through Illinois and Ohio. An underground power feed buildng in Beaucoup, Illinois, which contains its shielding solely from wire-tied reinforcing, was tested for both E- and H-field attenuation. The one-story building has inside dimensions of 32 feet by 92 feet, and a ceiling height of 12-1/2 feet. The roof top is approximately 2 feet below finished grade level. The reinforcement pattern is relatively heavy, since the building is designed for 10 psi overpressure. There is, however, no more steel in the building than is required for such structural strength. The entire grid of reinforcement — top and bottom layers — in the walls, roof, and floor, including the heavy concentration of steel around the columns is tied together, to provide shielding from nuclear weapon-induced electromagnetic pulse. The test results are shown in Table C. With the exception of one 24-dB result (at 95 MHz), the building shielding exceeds 25 dB at all frequencies above 50 kHz at which measurements were made. The shielding exhibited a dropoff of not more than 20 dB per decade below 50 kHz.

7.07 Shielding tests were also made on another building along the L5 route — a one-story, above-ground building in Berlin Heights, Ohio. In this building, the equipment area measures 40 feet by 40 feet. As in the Beaucoup building, the construction is of poured-in-place concrete with tied reinforcing bars providing the shielding. Because it has a lower overpressure specification, the Berlin Heights building contains less reinforcement than does the Beaucoup building. All penetrations are connected with steel wire to the reinforcing-bar structure of the building. For this building, Table C indicates a minimum attenuation of 47 dB for E-fields and 23 dB for H-fields, for frequencies at which measurements were made.

7.08 For comparison, Table D gives test measurements for an unshielded building in Polk City, Florida. This is a poured-in-place TD-2 radio relay building measuring 80 feet by 80 feet. Measurements were made in the basement and on the ground floor after telephone equipment had been installed. With no deliberate attempt at shielding, 24 dB and 5 dB of attenuation were achieved for E- and H-fields, respectively, in the 385 kHz to 1580 kHz range. The minimum H-field shielding values shown between 950 and 1080 kHz result from resonant currents in the microwave tower being brought into the building by waveguides to the TD-2 bays.

C. BRICK-AND-BLOCK WALL BUILDINGS

7.09 To determine the shielding provided by buildings of brick-and-block-wall construction, a study was made of a building planned by Cincinnati Bell in West Chester, Ohio. The site is close to both an AM broadcast transmitter and an extensive installation of powerful AM shortwave transmitters operated by the Voice of Amerrica. The building was planned to have reinforced concrete floors, roof, and columns, with brick-and-block exterior walls. The recommended shielding consists of

TABLE C

RFI SHIELDING OF POURED-IN-PLACE CONCRETE BUILDINGS

BUILDING LOCATION	FREQUENCY	SHIELDING (dB)	
		E-FIELD	H-FIELD
Beaucoup,[1] Illinois	18 kHz	41	18
	550 kHz	51	30
	630 kHz	55	30
	770 kHz	54	34
	850 kHz	62	36
	940 kHz	59	37
	1.18 MHz	52	38
	1.21 MHz	53	35
	95.1 MHz	24	-
Berlin Heights,[2] Ohio	18 kHz	-	11
	750 kHz	54.5	27.5
	790 kHz	55	23
	930 kHz	47	25
	1.10 MHz	55.5	36
	1.46 MHz	53	30
	92 MHz	-	2
	98 MHz	-	0.5

1. Underground building with tied reinforcing bars.
2. Above-ground building with tied reinforcing bars.

1/2-inch mesh of 1/16-inch metal wire. The shield would be built into the cavity of the brick-and-block walls, and cast into the roof and floor slabs. Calculations show that 30 dB of attenuation of RFI may be expected from this type of construction.

8. COSTS

8.01 The cost of providing RFI shielding in buildings appears to be as variable as the cost of the buildings themselves. However, while different types of construction and levels of shielding require a variety of shielding methods, the cost of the shielding can usually be effectively controlled by ingenuity and careful engineering of construction details.

8.02 The cost incurred in the construction of the buildings mentioned earlier illustrate the range of costs that might be expected when shielding a building for RFI. In the case of the two Illinois Bell buildings using an integral shielding system (Romeoville and Frankfort), the contractor could not identify any costs directly attributed to the shielding. While some of the shielding cost may have been covered elsewhere in the building cost breakdown, it appears that very little expense is incurred for integral shielding. On the other hand, the separate shielding applied to the brick-and-block exterior wall building in West Chester, Ohio was estimated at $34,000 for the 8,000 square feet of floor space, $4.25 per square foot.

8.03 The shielding costs of the offices reflect designs to shield against radiation at frequencies up to 100 MHz. In these installations, relatively coarse-grid shielding material is used, and the bonding of adjacent segments of the shield is relatively simple. If protection from radiation between 100 and 500 MHz is required, the shield becomes considerably more expensive. Bonding of the shield must be upgraded, and this raises the ***minimum*** cost of shielding to approximately $5.00 per square foot of building floor area.

9. TYPICAL CONSTRUCTION DETAILS

9.01 Figure 3 shows typical details of shielding in buildings of various construction. Figure 3 reflects two different shielding philosophies for either solid-sheet or mesh-type shielding: enclosure of the entire building, and the enclosure of individual stories. The labeled circles in this figure indicate areas for which details are given.

9.02 Area A is the intersection of the exterior wall and the roof. The detail is shown for a reinforced concrete roof with brick-and-block walls. The shielding is placed in the cavity of the wall and beneath the built-up roofing. The shield passes between two courses of block and is bonded to the roof shield. The detail for precast-concrete construction is also shown. Here the shield is cast into the precast elements, with

TABLE D

RFI SHIELDING OF TD-2 RADIO RELAY BUILDING

BUILDING LOCATION	FREQUENCY	SHIELDING (dB)			
		BASEMENT		GROUND FLOOR	
		E-FIELD	H-FIELD	E-FIELD	H-FIELD
Polk City, Florida[1]	18 kHz	-	7	-	9
	24 kHz	-	5	-	7
	34 kHz	-	4	-	11
	385 kHz	31	-	40	15
	530 kHz	24	13	33	12
	620 kHz	36	16	36	17
	740 kHz	29	16	33	12
	790 kHz	39	18	29	12
	950 kHz	29	13	26	5
	990 kHz	27	14	25	6
	1.08 MHz	35	11	28	9
	1.46 MHz	34	16	39	12
	1.58 MHz	32	16	27	10
	90 MHz	-	18	-	0
	92 MHz	-	37	-	6
	93 MHz	-	24	-	-1
	97 MHz	-	28	-	15

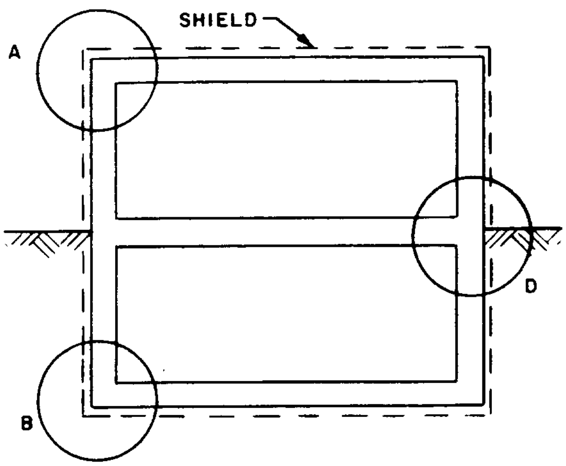
1. Unshielded poured-in-place concrete building with telephone equipment installed.

tails of the shielding left exposed at the appropriate places for interconnection.

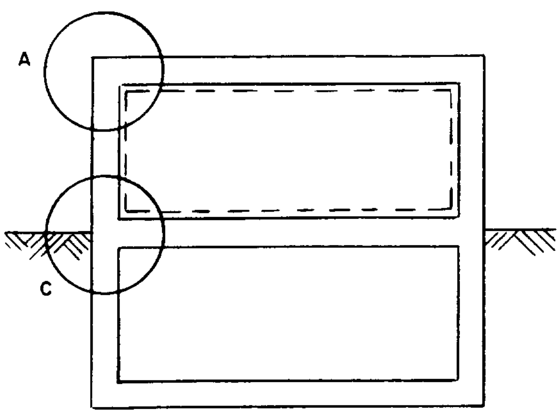
9.03 At the intersection of the basement wall and floor, Area B, the shield is placed in the floor, necessitating the use of a working slab. The shield, placed on the working slab before the structural slab is placed, is bonded to the shield cast into the wall.

9.04 When an individual story is shielded, the detail at Area C, the intersection of the wall and floor (or ceiling), is as shown. The wall detail is treated as in Area A, and the shielding at the floor is either cast into the structural slab by tying a large opening mesh to the reinforcing rods, or is an integral part of a raised-floor system.

9.05 Area D represents the intersection of the first floor, basement wall, and exterior wall. For brick-and-block walls, the shield is tied to the reinforcing bars before the basement wall is poured. The shield comes through the construction joint and is bonded to the wall shield. A similar scheme is used for precast concrete construction.

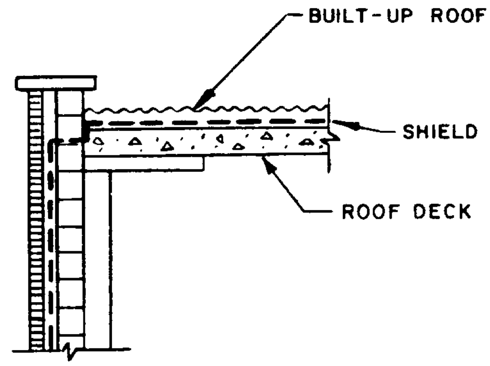


(1) SHIELDING OF WHOLE BUILDINGS

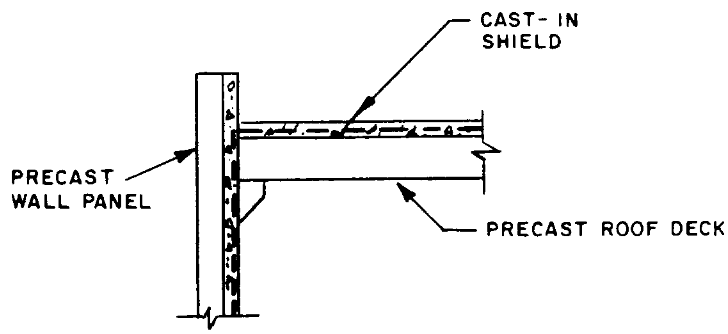


(2) SHIELDING OF INDIVIDUAL FLOORS

TWO APPROACHES TO SHIELDING

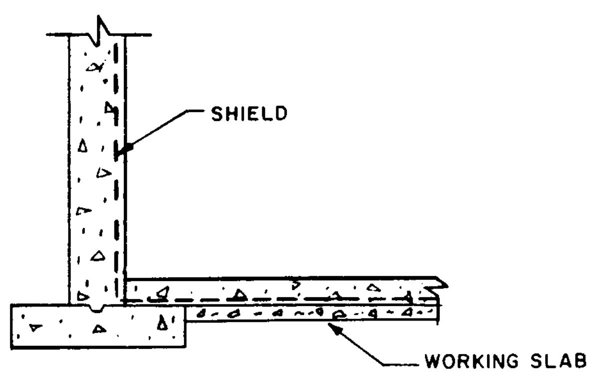


(1) REINFORCED CONCRETE FRAME WITH BRICK-AND-BLOCK CAVITY EXTERIOR WALL



(2) PRECAST CONCRETE CONSTRUCTION

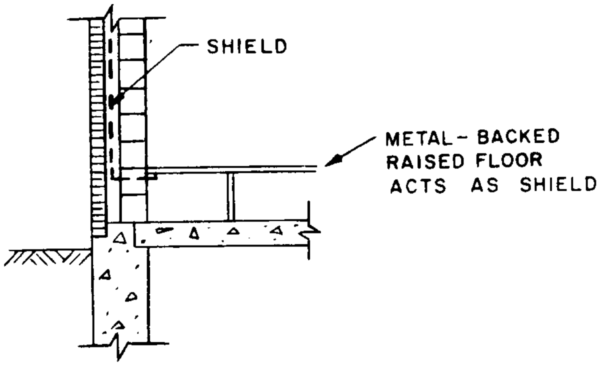
DETAILS OF AREA A



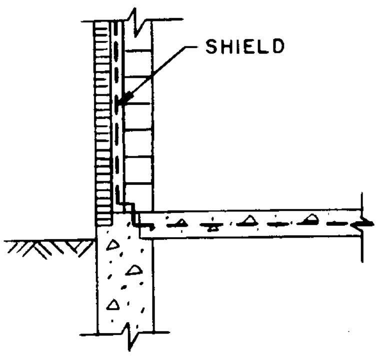
POURED FOUNDATION

DETAILS OF AREA B

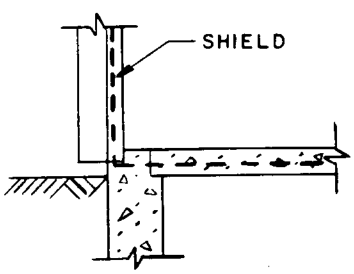
Fig. 3—RFI Shielding (Sheet 1 of 2)



(1) RAISED FLOOR SHIELD

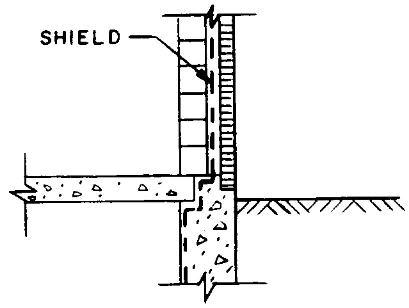


(2) BRICK-AND-BLOCK WALL

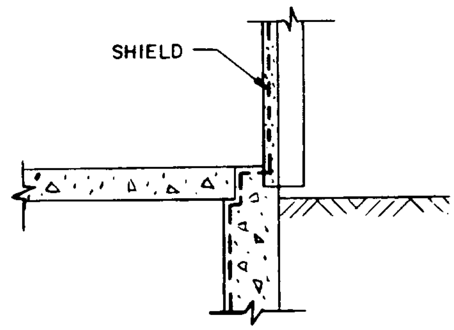


(3) PRECAST CONCRETE WALL

DETAILS OF AREA C



(1) BRICK-AND-BLOCK WALL
AT FOUNDATION



(2) PRECAST CONCRETE WALL
AT FOUNDATION

DETAILS OF AREA D

Fig. 3—RFI Shielding (Sheet 2 of 2)

10. REFERENCES

1. Section 760-850-010, "RFI Shielding Test Procedure."

2. EM 1314, "No. 1 ESS Electromagnetic Compatibility," March 21, 1969.

3. "Inductive Interference Engineering Guide," Bell Laboratories, March 1974.

4. "EMP Protection for Emergency Operating Centers," Department of Defense, OCD, May 1971.

5. "EM Shielding of Building Materials," C. M. Brennan, et al., Electro-Mechanics Company, Austin, Texas, February 1968.

6. "Proposed Specification for Electromagnetic Shielding of Enclosures and Buildings," Genistron Inc., Los Angeles, Cal., July 31, 1963.

7. "Electromagnetic Shielding Materials and Performance," Donald R. J. White and Dan White Consultants, Germantown, Md. 1975.

8. "Noise Reduction Techniques in Electronics Systems," Henry W. Ott, Wiley Interscience Div. of John Wiley & Sons, Inc., New York, 1976.

9. "Grounding and Shielding Techniques in Instrumentation," Ralph Morrison, John Wiley and Sons, Inc., New York, 1967.

10. "IEEE Transactions on Electromagnetic Compatibility, Special Issue on Shielding." March 1968, Volume EMC-10, Number 1, R. B. Schultz, Editor.

11. "Building Attenuation and the Impact on Product Susceptibility," S. Mir and Don White. IEEE Talk at 16th EMC Group Meeting, San Francisco, July 1974, Convention Record.

12. "Electromagnetic Screening, Theory and Practice," by J. Miedzinski. The Electrical Research Association Report #M/T135 1959. Issued by the British Electrical and Allied Industries Research Associates, Thorncroft Manor, Dorking Road, Leatherhead, Surrey, England.

13. "Protecting Communications Systems from EMP Effects of Nuclear Explosions," J. B. Hays. IEEE Spectrum, Vol. 1, May 1964.

14. "EMP Engineering and Design Principles," Department 4522 BTL, Whippany.

11. RFI SHIELDING STANDARDS

1. Determine the location and characteristics of all RFI sources within 1 mile of the equipment building, and calculate the field strengths for potentially troublesome sources.

2. Where troublesome levels are indicated, measure on-site field strength (see Section 760-850-010).

3. Provide building shielding where existing or expected RFI levels exceed 127 dB above 1 microvolt per meter at frequencies between 500 kHz and 1000 MHz.

4. Carefully design the building shield, paying close attention to bonding, penetrations, and grounding.

5. Measure the field strength within the completed building before any equipment is installed.