CHAPTER 4

THE TRANSMITTER STATION

4.1 GENERAL

Operational requirements determine the number and types of transmitters to be installed at a transmitter station. A small station may have only a few transmitters while a large one, supporting a large communications center, may have more than 100 covering various frequency bands and having power outputs varying from a few watts up to the megawatt range. Table 4-3 lists typical equipment that may be found at a transmitting station. However, the particular equipments required at the transmitter station to implement a specific circuit are shown by the applicable NAVELEX standard plan. See chapter two. Transmitters for the HF, MF, LF and VLF bands may all be located at the same transmitter station, but the discussion in this chapter is generally confined to HF transmitter systems which range from 1 kW to 200 kW peak envelope power (PEP) output. The high-power systems associated with MF, LF and VLF transmitters will be discussed in other handbooks to be published later and, therefore, are not addressed directly here.

The transmitter station is sited on reasonably flat or rolling terrain in accordance with the factors discussed in NAVELEX 0101, 103 — "HF Radio Propagation and Facility Site Selection." The transmitter building, located in the center of the antenna field (see figure 4-1), is designed to satisfy the operational requirements and to promote operational efficiency. At small stations the transmitters are located in a transmitter room and a control and monitoring facility is installed in an area central to the transmitters. The width of a typical transmitter room is 26 feet, which permits placement of two rows of transmitters facing front to front with an 8-foot-wide center aisle and with approximately 4 feet of space behind the transmitters. Large stations have transmitter buildings with 26-foot-wide wings arranged in the form of a "T," a cruciform, or a star with the control and monitor area placed at the junction of these wings. This concept is illustrated by figure 4-2. Associated systems and facilities such as microwave equipment for the intersite link, terminal equipment, an electronic repair shop, spare parts storage, and office space are located in separate rooms.

Information for transmission is received from the communications center via intersite links. The need for survivability and reliability may require the provision of alternate links routed over separate paths between the communications center and the transmitter site. Chapter 6 gives the intersite link requirements and general criteria for the type of link to be employed. The routing of each circuit within the station will be in accordance with the standard plans discussed in chapter 2.

4.2 HF TRANSMITTING EQUIPMENT

NAVELEX supplies general purpose independent sideband (ISB) transmitters as part of the planning to achieve operational flexibility. Present generation transmitters are capable of the classes of emission shown in table 4-1; they are designed for matched loading into 50-ohm coaxial transmission lines; and they may be tuned and placed into operation by operators at the equipment or by remote control from circuit operator positions.

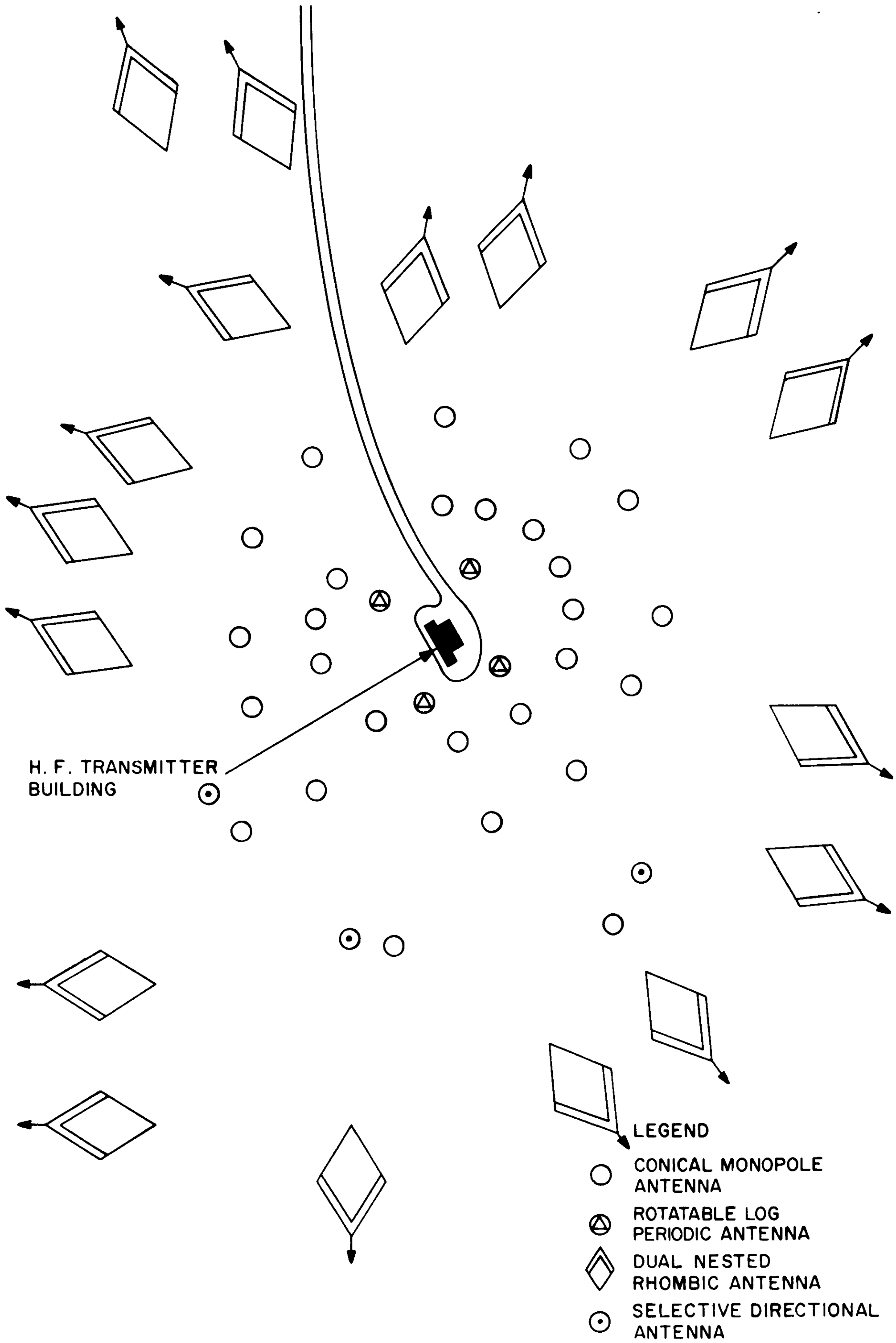


Figure 4-1. Transmitter Building Location

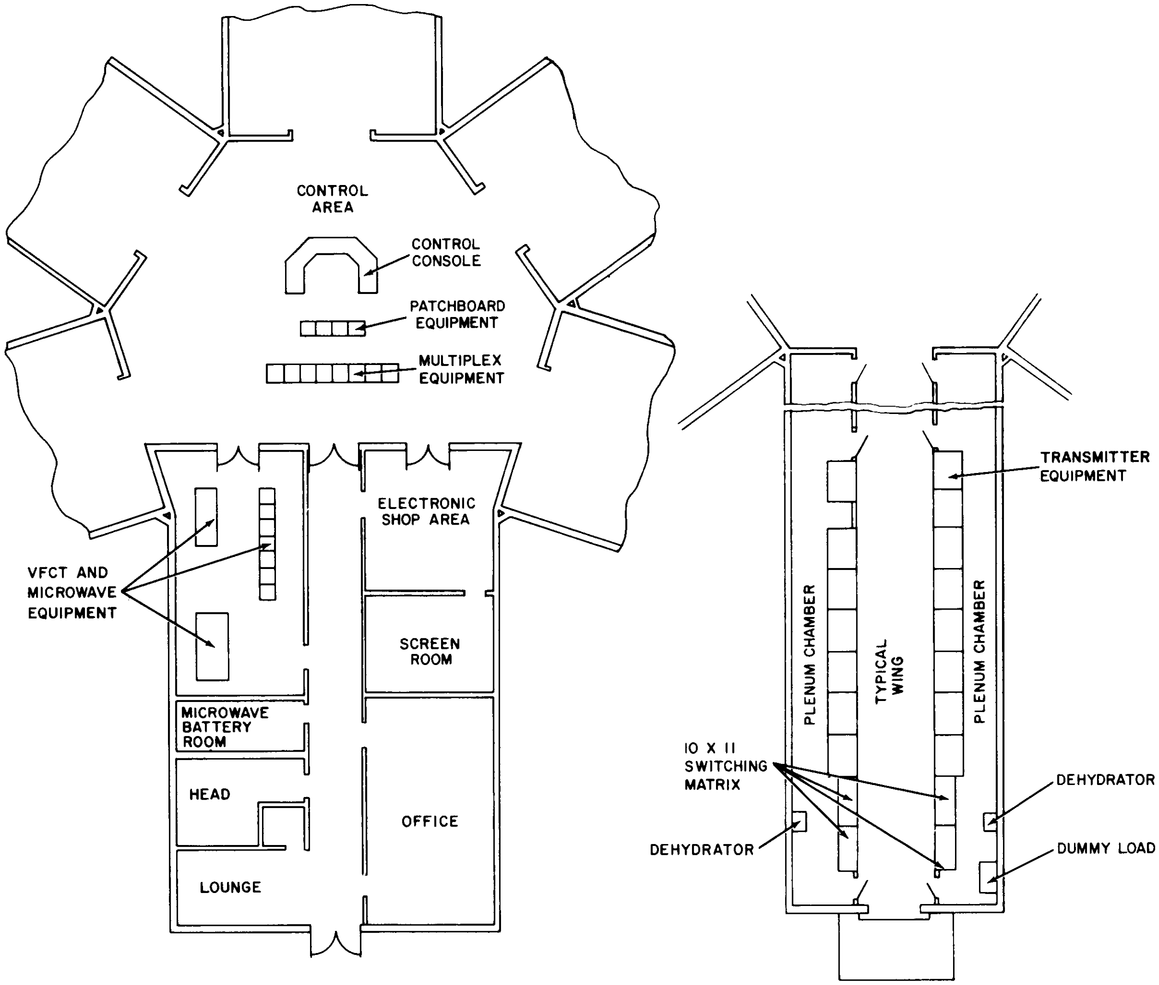


Figure 4-2. Large Transmitter Building and Plenum Concept

TABLE 4-1. EMISSION DESIGNATION

Designation	Description
0.1A1	Continuous wave, on-off keying telegraphy, 100-Hz bandwidth (CW Telegraph at 25 WPM)
1.7A7J	Amplitude modulated, multichannel, voice-frequency telegraphy, suppressed carrier, single sideband, 1700-Hz bandwidth (100 WPM, 8 channel)
3A3J	Amplitude modulated, telephony, suppressed carrier, single sideband, 3000-Hz bandwidth
3A7J	Amplitude modulated, multichannel voice-frequency telegraphy, suppressed carrier, single sideband, 3000-Hz bandwidth
3A9A	Amplitude modulated, combination telegraphy and telephony, reduced carrier, single sideband, 3000-Hz bandwidth
3A9J	Amplitude modulated, combination telegraphy and telephony, suppressed carrier, single sideband, 3000-Hz bandwidth. A single sideband, suppressed carrier, amplitude modulated emission occupying 3 kHz of spectrum and which does not fall into any of the preceding categories. Examples of emissions properly classified as 3A9J include data, simultaneous voice and tone telegraphy, simultaneous voice and data, or simultaneous data and telegraphy.
6A3	Amplitude modulated, telephony, double sideband full carrier, 6000-Hz bandwidth
6A3B	Two independent 3-kHz intelligence channels authorized for voice transmission. The suppressed carrier frequency is the same as the assigned frequency.
6A7B	Two independent 3-kHz intelligence channels for multichannel telegraphy transmission. The suppressed carrier frequency is the same as the assigned frequency.
6A9B*	Amplitude modulated, combination telegraphy and telephony, two independent sidebands, 6000-Hz bandwidth
9A3B, 9A7B 9A9B*	Amplitude modulated, combination telegraphy and telephony, three independent sidebands, 9000-Hz bandwidth
12A3B, 12A7B 12A9B*	Four independent 3-kHz intelligence channels for voice, multichannel telegraphy, or composite transmissions respectively. Suppressed carrier frequency is the same as the assigned frequency.
1.24F1	Frequency modulated, one of any two frequencies being emitted at any one instant, 1240-Hz bandwidth (100 WPM RATT)
4F4	Frequency modulated, facsimile transmission, 4000-Hz bandwidth

*Note that for 6A9B, 9A9B or 12A9B emissions, one 3-kHz intelligence channel may carry only voice and another only telegraphy and still fall within the definition of composite transmission.

Spare transmitters and associated equipment are provided for maintenance and backup on a basis of one spare for every five active units.

Transmitters are rated by their output power and are classified in accordance with the designations listed in table 4-2. General purpose ISB transmitters provided by NAVELEX are rated at either 1 kW, 10 kW, 40 kW or 200 kW PEP output.

4.3 TRANSMITTER CONTROL

A centralized area for control, monitoring and testing of transmitting systems is provided at each transmitter building on the station. This center includes provisions for all elements of transmitter control other than the switching of RF output and the initial turn-on of the transmitters. To facilitate operations, the following equipments may be incorporated in this area:

a. Patchboards for each transmitter DC or tone-key input and each sideband channel input.

b. Transmitter status indicators.

c. A display to show transmitter circuit employment and antenna assignment.

d. Controls for steerable antennas.

e. Teletype and voice communications equipment used to coordinate with the communications center.

f. Controls for remote transmitter tuning.

g. Circuit monitoring and test equipment such as frequency counters, oscilloscopes, spectrum analyzers, signal generators, and level measuring devices.

h. RF input and power output quality and level-indicating equipments.

i. A station frequency standard to ensure the accuracy and stability of transmitter frequency synthesizers.

Table 4-2. Standard Transmitter Power Designations

POWER	DESIGNATION	POWER RATING PEP
Low	LP	Under 1 kW
Medium	MP	1-5 kW
Medium High	MHP	5-20 kW
High	HP	20-50 kW
Very High	VHP	Above 50 kW

4.4 CHANNELIZATION AND ROUTING

Signal flow with a minimum of processing is preferred. It is desirable to transmit 3-kHz bandwidth audio signals in the same form as received from the communications center. When the signal at the output of the link demultiplexing equipment is routed directly to the transmitter, the resultant transmission is more likely to be error free and reliable. In order to approach this objective, the following design criteria are established for the links and for the information received:

a. All links to the transmitter site carry information on 4000-Hz nominal bandwidth link channels.

b. The information for each destination is received on a dedicated link channel (3-kHz bandwidth audio channel) or a voice frequency carrier telegraph (VFCT) channel which may be part of a 3-kHz bandwidth audio channel.

c. All signals received via the links are routed via patchboards to provide the flexibility to use any signal to modulate (or key) any transmitter.

Information that is to be transmitted by on-off keying (CW emission) or frequency shift keying (FSK emission) is received in the form of VFCT tones. The station VFCT terminal separates the tones into channels and converts the tones into DC keying signals that are routed through patchboards to the appropriate transmitter keyer or keyers.

Information for use within the station such as orderwire traffic and DC control signals is received in the form of VFCT tones via the intersite links. The station VFCT terminal separates these tones into channels and converts the tones into DC signals that are in turn routed via distribution frames and patchboards to teletype equipment or to the applicable transmitter. In-band control signals are also received at the transmitter station. In-band signaling incorporates control information with the information to be transmitted. Separation of the in-band control signals from the information to be transmitted is accomplished at the transmitter. Therefore, a straight-through type of transmission is possible because separate distribution of the control signal is not required.

All in-house signal and control information (both audio and DC) is distributed by overall shielded cabling. In general, the in-house circuit flow is from the link terminal equipment to a distribution frame, to a patchboard, back to a distribution frame, and then to the transmitter, orderwire terminal or other electronic equipment. The link channels between the communications center and the station are terminated on the transmitter station main distribution frame (MDF) and then routed to an intermediate distribution frame (IDF). The MDF and the IDF may be combined as long as distinctly separate areas are maintained within the frame.

4.5 SYSTEM FLEXIBILITY

4.5.1 Audio and DC Signal Flexibility

Maximum operational flexbility is achieved by installing circuit patchboards and distribution frames. The patchboards provide access for equipment maintenance, for signal monitoring and for rerouting of signals as required by operations in the event of an equipment failure. All circuit patchboards are wired "normal through" so that no patch cord connections are required when the system is operating as planned. Wiring criteria concerning frames and patchboards are discussed in chapter 9.

4.5.2 RF Signal Flexibility

RF switches provide signal flexibility by permitting transmitters to operate into selected antennas or into a dummy load to satisfy various frequency, directivity and maintenance requirements. Crossbar switching matrices are the latest approved switching devices. One of these matrices is shown in figure 4-3. The following criteria govern transmitter RF output switching:

a. One transmitter may feed only one antenna at a time.

b. Antennas connected to an RF switching matrix must be capable of handling the maximum output power of any transmitter terminated on the matrix.

c. Multicoupler inputs should appear on the antenna switching matrix.

d. Multicoupler outputs may appear on the antenna switching matrix if this degree of flexibility is economically justifiable.

e. When more than one matrix is installed, two input trunks and two output trunks are required between matrices to increase flexibility.

f. Each matrix should provide one output to a dummy load to permit transmitter tuning and testing without radiating radio signals.

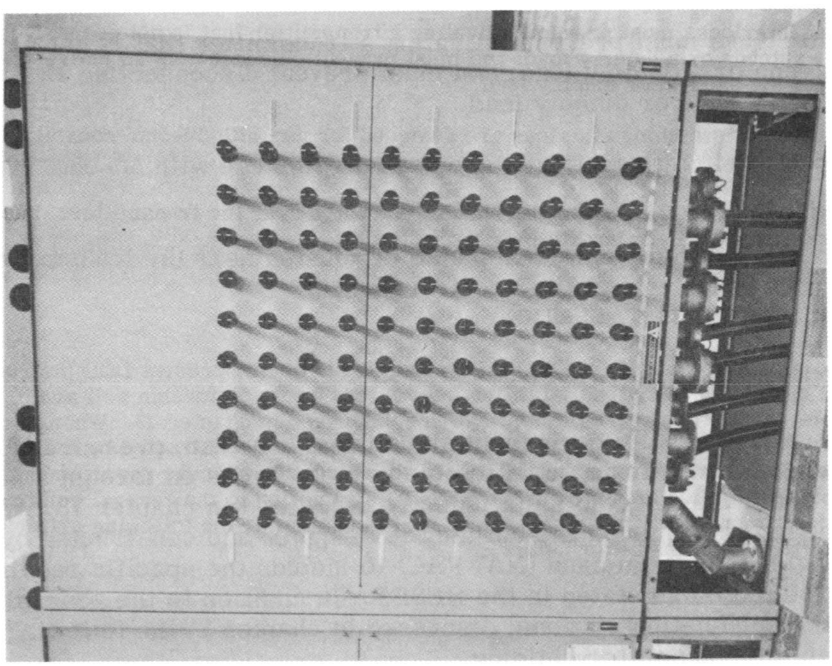
g. Electrical interlocks must prevent activating a transmitter that is not properly connected to an antenna or a dummy load, and must prevent disconnecting an active transmitter from the antenna or dummy load.

h. Transmitter RF switching matrices are designed for use with 50-ohm coaxial transmission lines.

i. Transmitter RF switching matrices should be located near the transmitters, but they should not be part of the transmitter control facility.

4.6 CONSTRUCTION AND INSTALLATION

Transmitter buildings are usually permanent structures; however, present DOD instructions state that new communications facilities in overseas areas on foreign soil are to be transportable. These transportable stations are discussed in chapter 13. When new, permanent construction is required, the building is designed and constructed by the Naval Facilities Engineering Command (NAVFAC) to include the specific requirements of the electronic installation as stated in the BESEP. In addition to the general building requirements for communication stations, discussed in chapter 7, the following criteria apply specifically to the transmitter building.



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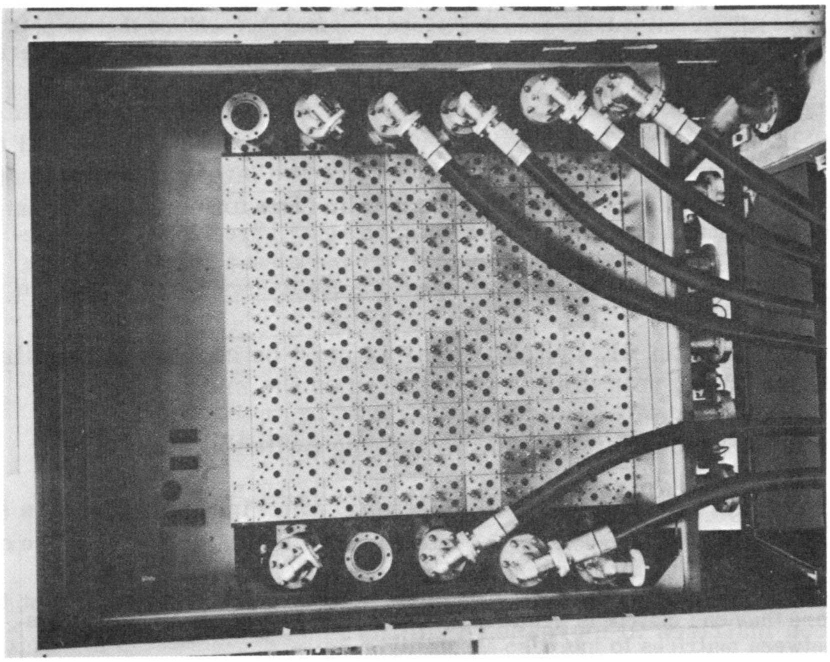

BACK

Figure 4-3. Transmitter Antenna Crossbar Switching Matrix

4.6.1 Building Features

a. The transmitter room (wings) and rooms for other electronic equipment will be windowless and free from obstructions and columns.

b. A central area is required for transmitter control, monitoring and testing. Preferably, this area should be chosen so that operators will be able to see all the transmitters.

c. The floor will be concrete and will be designed to support a loading of 200 pounds per square foot.

d. A truck loading platform is required at the end of each transmitter wing. Door access must be sufficient for the largest equipment or equipment subsection.

e. An electronic maintenance shop is required. This shop will contain a shielded room that provides 60 dB attenuation of electromagnetic radiation from 100 kHz to 100 MHz.

f. Cable vaults are normally installed to serve as the entrance for all RF and signal cables.

g. The building must include features that tend to isolate transmitter acoustic noise from the operating and control areas.

4.6.2 Building Environment

The need for equipment ventilating air and the requirements for cooling the building are based upon the climatic conditions and the heat generated within the building by personnel, lighting and equipment. The BESEP must specify the electronic equipment heat losses (unit and total) and the air flow (CFM) requirement (unit and total) for the electronic equipment. NAVFAC designs and installs the necessary environmental systems taking into account the electronic equipment heat losses and air flow requirements that are stated in the BESEP.

The preferred method for removing waste heat from transmitters is by ventilation with outside air. Heat is transferred directly to the air by passing the ventilating air directly over the parts to be cooled or indirectly by passing the air through heat exchangers that are integral parts of the transmitters.

Except for new-generation equipment, for which acceptable intake and exhaust static pressures have been specified, ducting of air to and from the transmitter is not recommended, since equipment static pressure capability may be exceeded. As a general rule, the transmitter itself must control the flow of ventilating air. The preferred method of supplying ventilating air to a transmitter is through the use of a plenum concept such as that illustrated by figure 4-4. With this method no head pressures are developed since air can flow freely through the transmitters even when the building supply and exhaust systems are secured.

As a side benefit, the plenum concept provides a degree of sound isolation by isolating transmitter blower and rushing air noises from the operating area. Moreover, it makes possible separate air conditioning for the portions of the building occupied by personnel.

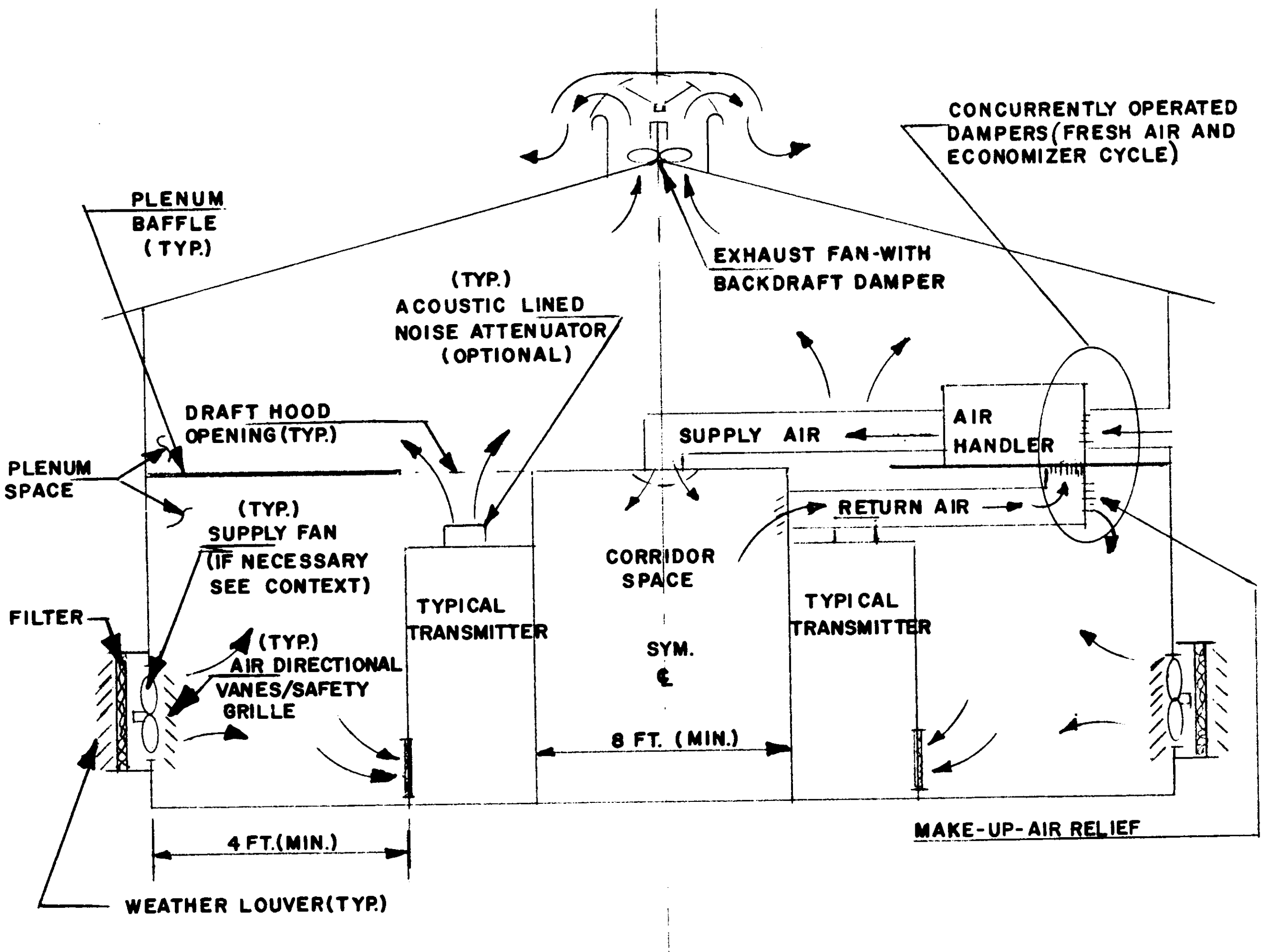

Figure 4-4. Plenum Concept

4.6.3 Building Grounding and Bonding

At this writing, studies are being planned which will result in establishing new criteria for the grounding and bonding of the transmitter building. At completion of the studies, these new criteria will be incorporated into this handbook. Meanwhile, NAVFAC DM-23—"Communications, Navigational Aids, and Airfield Lighting" should be used as the source of criteria for bonding and grounding of transmitter buildings.

4.6.4 Building Electrical Power

The electrical power requirements for electronic equipment are specified in the BESEP for use by NAVFAC or the NAVFAC Engineering Field Division (EFD) in designing the station electrical power system. The demand load for the transmitter building electronic equipment is 100% of the connected technical load. For new facilities the primary power should include design for 25% growth of the total electrical load. The primary power source for a transmitter facility is usually a commercial power company unless the commercial power is inadequate, in which case a class A power plant is installed. Factors that determine the adequacy of a commercial power company are contained in DM-4 — "Electrical Engineering." The following criteria are applicable to the transmitter building power system:

a. New facilities are to be designed around a 480-volt, 3-phase, either 50- or 60-Hertz system and are to have separate buses for the technical and nontechnical loads.

b. At new facilities, transmitters will require power as follows:

(1) Power amplifier: 480-volt, 3-phase, 3-wire from the technical bus.

(2) Exciter: 120-volt, single-phase from the technical bus.

(3) Transmitter utility outlets: 120-volt, single-phase from the nontechnical bus.

c. New transmitter equipment is adaptable for use at existing facilities which have 208, 230, or 240 volt systems; therefore the existing power distribution system normally is used when new equipment is installed. Changing to a 480-volt distribution system will be authorized in connection with making building additions or increasing power capacity only if economically justifiable.

d. For personnel safety, positive disconnect switches operable from the rear of the transmitters must be installed in the line supplying each transmitter power amplifier. The equipment circuit breaker that is operable only from the front of the transmitter is not sufficient for this safety disconnect. When plenum chambers are used this safety disconnect must be inside the plenum near the back of the transmitter.

e. A separate circuit breaker for the exciter of each transmitter must be installed at the technical power panel.

f. Class D, no-break power is not provided for a transmitter building.

g. The need for emergency power is considered on a case-by-case basis. When such power is included, it will be tailored to meet the selected communications requirements upon which the need is based.

4.6.5 Building Siting

The transmitter building is located in the center of the antenna park to minimize the length of the antenna transmission lines. The following planning distances have been established for separating the transmitter station from other facilities.

a. Overhead high-tension power lines, 1000 feet from the nearest antenna.

b. Main highways, 1000 feet.

c. Other transmitter stations, 3 miles.

d. Airfields and glide paths, 3 miles when the station is used for general purpose communications.

e. Airfields and glide paths, 1500 feet when the station is used in conjunction with air operations.

f. Receiver buildings and associated antenna fields, 25 miles when VLF transmitters are installed.

g. Receiver buildings and associated antenna fields, 15 miles when LF and HF transmitters are installed.

h. Salt water. The transmitter building should be located at least 1/2 mile from the salt water if possible. This recommendation is to avoid corrosive effects of salt air on transmitters ventilated with outside air. If it is not possible to meet this siting requirement, then more emphasis should be placed on consideration of utilizing mechanical refrigeration for cooling the entire building space.

Table 4-3. Typical Transmitter Station Equipment

TAB-02 TRANSMITTER

CLASS	NOMENCLATURE	FREQ RANGE	EMISSION	STABILITY	MAX POWER OUTPUT (KW)	ANTENNA Z (OHMS)	HEAT DISSIPATION WATTS	HEAT DISSIPATION BTU/HR	ENVIRONMENT HUMIDITY	ENVIRONMENT TEMP	PRIMARY POWER KW	PRIMARY POWER VOLTS	PRIMARY POWER PHASE	PRIMARY POWER FREQ (HZ)	SHIPPING DATA NO OF PKG	SHIPPING DATA VOL (CU FT)	SHIPPING DATA WEIGHT (LBS)	MAJOR COMPONENT DIMENSIONS ITEM	HEIGHT (IN)	WIDTH (IN)	DEPTH (IN)	WEIGHT (LBS)	ADDITIONAL DATA	STANDARD INSTL PLAN DWG NO
LIMITED STANDARD	AN/FRT-39B	2 TO 20	A1, A3, A3A, A3B, A0, A4, F1, F4	1 IN 10^8 PARTS/DAY	10 PEAK ENVELOPE POWER 5 AVERAGE	50 UNBAL 600 BAL	15000	51.225	90%	0° C TO 50° C	20 PF .8	200 TO 250	3	50-60	13	260.0	4243	COMPLETE UNIT	84	56	44	2800		
LIMITED STANDARD	AN/FRT-39C	2 TO 30	A1, A3, A3A, A3B, A0, A4, F1, F4	1 IN 10^8 PARTS/DAY	10 PEAK ENVELOPE POWER 5 AVERAGE	50 UNBAL. 600 BAL.	15.000	51.225	90%	0° C TO 50° C	20 PF .8	200 TO 250	3	50-60	13	260.6	4243	COMPLETE UNIT	84	56	44	2800	SHIP BOARD MODEL	
LIMITED STANDARD	AN/FRT-39D	2 TO 30	A0, A1, A3, A3A, A3B, A4, F1, F4	1 IN 10^8	10 PEP 5 AVERAGE	50 UNBAL. 600 BAL.	15.000	51.225	90%	0° C TO 50° C	15 PF .8	230	3	50-60	13	260.6	4243	COMPLETE UNIT	84	56	44	2800	VARIOUS AN/FRT-39 MODULES INTERCHANGEABLE	
STANDARD / LIMITED STANDARD	AN/FRT-40A, 40B / AN/FRT-40C	2 TO 28	A3B, A4, F1, F4, A0, A1, A3, A3A	1 IN 10^8 PARTS/DAY	40 PEP 20 AVERAGE	50 UNBAL 600 BAL.	40.000	136.000	90%	0° C TO 50° C	72.5 PF .85	208 TO 230 460	3	50-60	3	260.6	10.922		84	126	36	7000		
STANDARD	AN/FRT-62, 62A	2 TO 28	A0, A1, A4, F1, F4	1 IN 10^8 PARTS/DAY	200 PEP 100 AVERAGE	50 UNBAL. 600 BAL.			95%	0° C TO 50° C	400 PF .9	208 OR 460	3 3	50-60	69	2600	3600		84	282	40	26000		
STANDARD	AN/FRT-70	2 TO 30	A0, A1, A4, F1, F4	1 IN 10^8 PARTS/DAY	1 PEP	50 UNBAL.	2700		95%	0° C TO 50° C	3.84 PF .8	230	1	50-80										
STANDARD	AN/FRT-72	.030 TO .150	A0, A1, A2, A3, A3A, A3B, A3J, A9B	1 IN 10^8	100 PEP 50 AVERAGE	50 UNBAL.	85.000	290.275	95%	0° C TO 50° C	120 PF .9	460	3	50	17	504.26	10252	TRANSMITTER AMPLIFIER MODULATOR POWER	38 36 36 36	208 78 78 78	75 48 48 48	9530 1110 2220		
STANDARD	AN/FRT-72 A & B	.030 TO .150	F1, F4, A0, A1, A2, A3, A3A, A3B, A3J, A9B	1.2 - 10^8	100 PEP	50 UNBAL.	85.000	290.275	95%	0° C TO 50° C	120 PF .9	460	3	50	17	504.26	10252	TRANSMITTER	78	208	36	9530		RW 10F 2175 RW 10F 2176
STANDARD	AN/FRT-74	.050 TO 500	A1, A3, A3A, A3A, A3B, A3J, F1, F4	1 IN 10^8	10 PEP	50 UNBAL.	15.000	51.225	95%	0° C TO 50° C	20 PF .85	208 TO 230	3	50-60		270	4300	TRANSMITTER	84	56	43 1/4	2800	EXTENDED FREQUENCY COVERAGE TO 540 KHZ WITH REDUCED POWER	
LIMITED STANDARD	AN/FRT-75	.100 TO 500	A1, F1	1.2 - 10^8	10 PEP	50 UNBAL.	10.000	34.150	95%	0° C TO 50° C	15 PF .75	230	3	50-60				TRANSMITTER EXTERNAL COOLING SYSTEM	84 24	58 24	44 36	1900	POWER AMPLIFIER - SINGLE	
STANDARD	AN/FRT-83V	2 TO 30	A0, A1, A2, A3, A3B, A3C, A3J, A9B, F1, F4	1 IN 10^8	1 PEP 1 AVERAGE	50 UNBAL.	3.000		95%	0° C TO 50° C	4 PF .85	220 OR 380 AND 120	3	50-60	1	21.6		TRANSMITTER	84	21 1/2	24	800		0100315
STANDARD	AN/FRT-84V	2 TO 29.9	A0, A1, A2, A3A, A3E, A3J, A9B, F1, F4	1 IN 10^8	10 PEP 5 AVERAGE	50 UNBAL.	15.000		95%	0° C TO 50° C	20 PF .85	220 OR 440 AND 120	3	50-60	2	10.0	2800	TRANSMITTER	84	40	54	2800		0100316
STANDARD	AN/FRT-85V	2 TO 30	A0, A1, A3A, A2, A3B, A3J, A9B, F1, F4	1 IN 10^8 PARTS/DAY	40 PEP 20 AVERAGE	50 UNBAL.	51.000	174.165	95%	0° C TO 50° C	71 PF .9	220 - 240 OR 440 - 480 AND 120	3 1	50-60 50-60	8	19.9	9405	TRANSMITTER	84	132	21	375		0100317
STANDARD	AN/FRT-86	2 TO 30	A0, A1, A2, A3A, A3B, A3J, A9B, F1, F4	1 IN 10^8 PARTS/DAY	200 PEP 100 AVERAGE	50 UNBAL.	270.000	922.000	95%	0° C TO 50° C	356 PF .9	200-240 OR 440-480 AND 120	3 1	50-60 50-60	14			TRANSMITTER	83.40	275	43 1/2	17.000		0100318
SUB STANDARD	AN/WRT-19( )	2-30	A1, A2, A3, A3A, F1, F4	1 IN 10^8 PARTS/DAYS	1 PEP	50 OR 70 UNBAL			90%	0° C TO 50° C	2.2 PF .8	115 230	1	50-60		/3	1253	TRANSMITTER	20 5/8	22 1/2	74 1/4	875		
LIMITED	TAB SERIES	.100 TO .555	A1, A2	MASTER OSCILLATOR	2	R= 2-12Ω C= 1000 - 2500 MMF	7500	25612			8.4 PF .8	230 460	3	60	6-10	217.6 TO 334.6	4537 TO 6130	TRANSMITTER POWER UNIT	37 10	88 20 17/16	57 1/2 20 11/16	1133 1170		

REVISIONS: ZONE, SYM, DESCRIPTION, DATE, APPROVED — A: SHEETS 1-5 COMBINED INTO SHEET 1

REFERENCES

NAVELEX STANDARD PLAN NO 0100498

NAVAL ELECTRONIC SYSTEMS COMMAND

GENERAL SERVICE — FOR SHORE USE

EQUIPMENT SELECTION LIST RF TRANSMITTERS - TAB-02

DRAWN / CHECKED / ACQ ENGR / APPROVED / PROJ ENGR / SPONSOR / SECT HEAD

F — A — SHEET 1 OF 1