802-000-901 SW
Issue A, September, 1973
S. W. Bell Tel. Co.

POWER PLANT ENGINEERING

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (CONT.)

LIST OF FIGURES (CONT.)

Sheet Index

Each individual sheet of Issue A of this practice is dated September, 1973.

PART A - SECTION 1.0

PURPOSE AND PROCEDURE FOR UPDATING

1.1 Purpose

This power plant engineering practice is intended to complement existing power plant engineering documents and aid the Telephone Company engineer in adequately administering and engineering all phases of telephone power plant equipment. It also provides information which will assist Plant personnel in day-to-day monitoring of power plant equipment. In addition, the basis and procedures for transmitting engineering information to Western Electric engineering are outlined.

Each section is arranged to give the engineer a working knowledge of a portion of the power plant equipment and to outline his engineering responsibilities. In outlining these responsibilities, it is assumed that most central office power plant engineering work will be handled on an E,F&I basis. Although knowledge of the procedures outlined in this practice should assist in preparing the Telephone Company engineer for TCE work, no attempt has been made to outline the detailed responsibilities required in handling the engineering on a TCE basis.

This practice also brings together information from other documents in an attempt to reduce time spent in researching power matters. In addition, the formats to be used in presenting the power plant data in an estimate and specification are outlined.

There will be occasions when the policies and methods outlined in this practice are found to differ from those in the AT&T Power Engineering Manual. This practice is to prevail in those instances, since it reflects the present policies of Southwestern Bell Telephone Company.

1.2 Procedures for Updating Practice

It is intended that this practice be updated as needed by individual sheet reissue. Each page will carry an issue date. A page-issue date index will be provided as part of this practice and will normally be reissued whenever an individual page is revised.

Suggestions concerning additions, changes or corrections in this practice should be submitted in accordance with procedures outlined in the Southwestern Bell addendum to BSP 000-010-015.

PART B - SECTION 1.0
INTRODUCTION

1.1 General Responsibilities

Perhaps no other single segment of telephone equipment is as important as power, for without it the entire system ceases to function. The Telephone Company engineer has the responsibility to see that adequate power, in the proper voltages, is available when needed. To provide too little power is disastrous; to provide too much is expensive and uneconomical. Adequate planning is the key to successful power plant engineering.

While the Telephone Company equipment engineer is responsible for providing adequate power equipment, this cannot be accomplished without proper support from the Plant Department maintenance forces. Plant personnel have the key responsibility of furnishing drain and load readings which not only indicate the adequacy of existing equipment but are essential in projecting requirements for future equipment. They also have the responsibility of alerting the Telephone Company equipment engineer to any unusual conditions or hazards that exist or appear imminent. Plant personnel are also responsible for proper maintenance of the power equipment once installed.

1.2 Basis for Engineering

Engineering adequate power plant equipment involves a two-step process: (1) the power requirements for the presently installed equipment, if any, must be determined (drain and load readings are essential) and (2) accurate projections of future requirements (including calculations for new equipment) must be made to insure proper sizing and timing of power equipment additions and removals. If the drain associated with the presently installed equipment forms the base upon which future requirements are projected, it is important that load and drain studies be made during periods which accurately reflect the power requirements of the telephone equipment. To assume loads similar to those experienced during peak operating periods (as Mother's Day, Christmas or disasters) would result in a more than adequate margin of safety and require considerable additional expenditures. On the other hand, engineering based on something other than the normal busy period of the equipment served results in an inadequate margin of safety.

In an equipment entity experiencing variable loads, the load (and resultant power requirement) experienced during the busiest hour of the busiest period of the year (ignoring the peak periods discussed previously), becomes the basis for engineering both equipment and power requirements. This normal busy period is usually referred to as the busy hour of the busy season or, many times, simply the busy hour (BH). The month(s) of the year in which the busy season occurs depends on many factors. Characteristically, this busy season will occur during the same month(s) year after year unless there is a significant change in the calling habits of the served customers.

PART B - SECTION 2.0
PLANT CHARACTERISTICS, SELECTION AND ENGINEERING CONSIDERATIONS

2.1 Information Sources

Various sources are available for obtaining engineering information about power equipment.

The Bell System Practices (BSP's) provide information concerning the engineering and maintenance of power equipment. Most engineering information will be contained in the 802 series (Equipment Design and General Equipment Requirements and Engineering Information - Power Systems). However, additional information may be obtained from the following sections or series:

026-3XX-XXX Circuit Breakers, Compensators, Contactors, Control Panels, Fuses and Mountings, Magnetic Switches and Starters

065-XXX-XXX Miscellaneous Equipment

155-XXX-XXX Alternators, Engine-Alternators, Gas Turbine Alternators, Tone Alternators, Tone Machines, Ringing and Coin Control Generators, Charging Generators and Motor Generators

157-XXX-XXX Batteries

159-XXX-XXX Engines and Engine Sets, Motors and Dynamotors and Drives

163-XXX-XXX Interrupters, Ringing Machines and Pole Changers

167-XXX-XXX Power Plants, Power Units and Power Supply

171-XXX-XXX Miscellaneous Power Circuits and Equipment

770-280-XXX Maintenance of Building Switchgear

800-610-165 Circuit Voltage Limits

The AT&T Power Engineering Manual (green book) is an excellent reference manual for many areas of power engineering and many of the procedures outlined in this practice make use of its information or tables. Since this manual was published in April, 1967, care must be exercised in using some of the material. Power equipment made available since its publication will not be shown and, of course, the cost data is now obsolete. Equipment tables included in this practice have been updated to include those plants not included in the AT&T Power Engineering Manual.

The equipment (J and ED) and circuit (SD and T) drawings also provide engineering information for the various power systems. The CD's (circuit description) will also provide detailed information concerning circuit operation.

The new power plant engineering questionnaires (E-1896 for dial, manual and toll offices; E-1896P for No. 1 and No. 2 ESS offices) are, in addition to being a guide for specification preparation, an excellent reference source. The new questionnaires have been updated to include notes referencing the BSP sections covering a particular piece of power equipment.

The above information sources will normally provide, along with the procedures outlined in this practice, the information necessary for selection of a new power plant. Other reference sources are listed in Part E of this practice.

2.2 Plant Selection

In selecting a plant for a particular application, the following procedures should be followed:

1. Determine the nominal operating voltages of the equipment to be powered and the corresponding operating voltage requirements of the plant or plants.
2. Determine the initial and projected (usually for a 20 year period) loads on the plant or plants.
3. Considering the availability of building floor space, establish the reasonable alternatives for satisfying the requirements determined under steps 1 and 2.
4. Complete an economic comparison study, considering both initial and recurring costs. This, of course, assumes that more than one reasonable alternative is available to satisfy the requirements of steps 1 and 2.

The four steps outlined above are proposed as a method of choosing a power plant for a specific application. Although each of the sections covering other equipment (emergency engines, batteries, ringing machines, etc.) cover criteria for selection, step 1 above can be modified to cover any type of power equipment. Steps 2 thru 4 can then be used in selecting the appropriate plan of action.

To see how these steps can actually be applied in selecting a plant, let's consider the following example:

An existing SXS toll center and its tributaries are scheduled for conversion to DDD in December, 1974. At the same time, another toll center will be downgraded and recentered on the SXS toll center. The office presently has a 110A, -48-volt power plant, with a 520-amp capacity. The +130-volt plant is a 410A with 40-amp capacity. For simplicity, the other plants in the office will be ignored. Upon completion of the DDD job, the following types of equipment will be installed in the office: No. 1 SXS (local), SXS CAMA and intertoll, ANI, 3CL switchboards, 23 information desks, No. 12 service observing boards, a 6A announcement system, No. 14 local test desks, N1 carrier, N3 carrier, O carrier and E-type signalling equipment.

In accordance with the recommended procedures (step 1), the nominal and normal voltage ranges of the equipment listed previously should be determined. Consulting BSP 800-610-165 (Circuit Voltage Limits) the following requirements are determined:

Equipment	Nominal Voltage	Normal Voltage Range
No. 1 SXS	-48	48-50, 50-52
SXS Intertoll	-48	48-50, 50-52
	+130	125-135
3CL switchboards	-48	48-50
23 information desks	-48	48-50
No. 12 service observing boards	-48	48-50
	+130	125-135
6A announcement system	-48	48-50
No. 14 local test desks	-48	48-52
	+130	125-135
N1 Carrier	-48	46-52
	+130	125-136
N3 Carrier	-48	46-52
	+130	125-136
O Carrier	-48	46-52
	+130	125-136
E SF equipment	-48	45-50

In reviewing the normal voltage ranges, it can be seen that a -48-volt plant with a normal operating voltage range of 48-50 volts and a +130V plant which will operate in the range of 125-135 volts are needed. Remember, for simplicity only -48-volt and +130-volt requirements are being considered. It can be seen from BSP 800-610-165 that power of other nominal voltages is also required for this equipment.

Using the techniques outlined in section B, parts 4.3 and 4.5, an estimate must be made of drain requirements (step 2 in our procedures) over a 20-year period in order to make a valid economic comparison.

Assume that the estimating techniques have been applied and the following total drain requirements determined:

Year	Drain, -48 Volts	Drain, +130 Volts
1974	610	55
1976	720	70
1978	860	90
1980	1000	110
1982	1200	140
1984	1470	160

Year	Drain, -48 Volts	Drain, +130 Volts
1986	1690	185
1988	2020	210
1990	2400	230
1992	2700	250
1994	3000	275

Step 3 suggests that the reasonable plans available for caring for these drain requirements now be established. It will be assumed that a building addition is being completed in 1974 and will provide sufficient floor space in the basement for all power equipment required through 1994.

Considering first the -48-volt requirements, there appears to be two reasonable plans for caring for the power requirements. (Figure 2.5 in part B, section 2.3 may be used in selecting the plants to be considered for application. Knowing that 50-volt operation is required, items 2 and 3 should be checked for standard plants capable of 50-volt operation. In this case, four can be found: 105E, 111A, 302B and 303A. In reviewing the discharge load capacities of these plants under item 6, it is apparent that only the 302B and 303A plants are large enough for use in this case.) They are shown below with the estimated cost by years associated with each plan.

Year	Drain	Plan I - Provide a 303A plant initially; replace with a 302B when required *	Plan II - Install a 302B plant initially *
1974	610	$58,800 - C: install new 303A (2000-amp) E/W 3 - 400-amp rectifiers *	$64,300 - C: install new 302B (6000-amp) E/W 2 - 800-amp rectifiers *
1976	720	---	---
1978	860	$9,900 - C: Add 1 - 400-amp rectifier (#4)	$16,000 - C: Add 1 800-amp rectifier (#3)
1980	1000	---	---
1982	1200	---	---
1984	1470	$9,900 - C: Add 1 - 400-amp rectifier (#5)	---
1986	1690	$9,900 - C: Add 1 - 400-amp rectifier (#6)	$16,000 - C: Add 1 800-amp rectifier (#4)
1988	2020	$96,300 - C, $5,000 - X, $37,000 - salvage: Add new 302B (6000-amp) E/W 4 - 800-amp rectifiers; remove 303A	---

* The cost of batteries, emergency engines and removal of existing plants are assumed to be common to both plans and are therefore neglected. Actually, the difference in FVPC used in battery calculations would result in different battery requirements for the two plans.

Since the two plans are identical from this point on, cost determinations for the years 1990-1994 need not be made. As suggested in step 4, the costs and timing for additions required for providing our -48-volt power have now been determined.

Now, turning to the +130-volt power requirements, figure 2.5, section 2.3 can again be used to determine that two plans of action are available for caring for the +130-volt requirements:

Year	Drain	Plan I - Install a 411 or 412 type (120-amp) plant initially; replace with a 708A (1000-amp) when required *	Plan II - Install a 708A (1000-amp) plant initially *
1974	55	$6,700 - C: install new 411 or 412 plant E/W 3 - 30-amp rectifiers *	$38,000 - C: install new 708A plant E/W 2 - 100-amp rectifiers *
1976	70	$2,000 - C: add 1 - 30-amp rectifier (#4)	---
1978	90	---	---
1980	110	$2,000 - C: add 1 - 30-amp rectifier (#5)	$6,800 - C: add 1 - 100 -amp rectifier (#3)
1982	140	$44,800 - C, $4,000 - X, $7,000 - salvage: remove 411 or 412 type plant; add new 708A E/W 3 - 100-amp	---

* The cost of batteries and removal of existing plants are assumed to be common to both plans and therefore are neglected. Actually, the different FVPC used in battery calculations would not result in the same battery requirements under each of the two plans.

To properly evaluate the costs of providing -48 and +130-volt power, the costs of both plans over the total study period must be weighed against initial capital requirements for each of the plans. A study technique has been developed for making this type of economic comparison and is commonly referred to as a present worth of annual charges or PWAC study. Details of this study technique are outlined in the AT&T publication, Engineering Economy, pp. 140-146. Fortunately, a time shared computer program has been developed for handling the mathematics of the study. The costs of our proposed -48 and +130-volt plans have been summarized in figure 2.1 for input into the time shared program. Individuals not acquainted with either the program or time shared computer input may contact the Area time shared computer coordinator for assistance in running and evaluating the results of the program.

The outputs of the PWAC study for the -48 and +130-volt plants are shown in figures 2.2 and 2.3 respectively. In both cases, the PWAC study indicates that plan I is the more economical alternative. In the case of the 48-volt plans, there is very little difference in the plans and the decision may be made to spend the additional $13,500 and install the 302B plant initially. However, as pointed out in AT&T's Engineering Economy, it may be desirable to implement plan I in order to take advantage of any new technologies available when the 303A plant has to be replaced in 1988. A sensitivity analysis may also be made to see how susceptible the two plans are to unexpected changes in the demand for 48-volt power.

In the 130-volt study, it's apparent that initial installation of the 411 or 412 plant is the most economical alternative. A selection must now be made from the 411A, 411B, 412A or 412B plants. The

PWAC Comparison

-48 volt study

Year (#)	Plan I - Install new 303A plant initially; replace with 302B when required	Plan II - Install new 302B plant initially
1974 (0)	$50,800 - 637C	$64,300 - 637C
1978 (4)	$9,900 - 637C	$16,000 - 637C
1984 (10)	$9,900 - 637C	-
1986 (12)	$9,900 - 637C	$16,000 - 637C
1988 (14)	$96,300 - 637C	-
	$5,000 - 637X	
	$37,000 - Salvage	

+130 volt study

Year (#)	Plan I - Install a new 411 or 412 type plant initially; replace with a 708A when required	Plan II - Install a new 708A plant initially
1974 (0)	$6,700 - 757TC	$38,000 - 757TC
1976 (2)	$2,000 - 757TC	-
1980 (6)	$2,000 - 757TC	$6,800 - 757TC
1982 (8)	$44,800 - 757TC	-
	$4,000 - 757TX	
	$7,000 - Salvage	

Figure 2.1 - Study Results Summarized for Input to PWAC Program

48V COMPARISON

ACCUMULATION OF PWAC (000) BY YEARS

	PLANS	
YEAR	1	2
1	11	14
2	21	26
3	30	38
4	39	49
5	48	62
6	57	73
7	65	83
8	72	93
9	79	102
10	85	110
11	91	117
12	97	124
13	103	132
14	109	139
15	120	145
16	128	151
17	135	156
18	142	161
19	149	165
20	155	169

Figure 2.2 - PWAC Study, -48-Volt Plans

130V COMPARISON

ACCUMULATION OF PWAC (000) BY YEARS

	PLANS	
YEAR	1	2
1	1	7
2	2	14
3	4	21
4	5	27
5	6	32
6	7	37
7	9	42
8	10	47
9	17	52
10	22	56
11	26	60
12	30	63
13	33	67
14	37	70
15	40	72
16	42	75
17	45	77
18	47	79
19	49	81
20	51	83

Figure 2.3 - PWAC Study, +130-Volt Plans

A arrangements provide for mounting the equipment in duct - type bays. The B arrangements mount the equipment in cabinets. Where adequate floor space is available, the cabinet bays (or B arrangements) should be provided since (1) they are capable of mounting more equipment in each bay and (2) they provide greater protection for the equipment.

Our choice, therefore, lies between the 411B, 63-cell plant, and the 412B, 66-cell plant. Figure 2.4 provides the criteria for making the selection between a 63-cell and 66-cell, 130-volt plant. This plot of lower emergency voltage limits at the batteries versus final volts per cell (FVPC) indicates that battery calculations should be made using FVPC between 1.75 and 1.90 (see part B, section 7.4). In looking at figure 2.4, it's apparent that a 63-cell plant should be used where the highest low emergency voltage limit at the batteries lies between 110 and 115.5 volts. Use of a 66-cell plant, although physically possible, would either (1) require discharge to less than 1.75 volts/cell at an unpredictable rate or (2) require use of 1.75 as the FVPC, thereby resulting in more battery plant being provided than actually required. In the region between 115.5 and 120 volts, either a 63- or 66-cell plant may be provided. The cost of the 3 additional batteries and CEMF equipment in the 66-cell plant must be weighed against the possible cost of a larger battery string in the 63-cell plant (as a result of a higher FVPC). An economic study may be required to make this selection, but in general, a 63-cell plant should be used in slow - growing (130-volt power requirements) offices and a 66-cell plant in moderate or fast - growing offices. Above 120 volts, a 66-cell plant must be used since use of a 63-cell plant would require a FVPC above 1.90.

In reviewing BSP 800-610-165, the following lower emergency voltage limits at the equipment fuse panels apply for +130-volt power:

SXS intertoll	- 120 volts
No. 12 S.O. Board	- 125 volts
No. 14 L.T.D.	- 125 volts
N1 carrier	- 117 volts
N3 carrier	- 117 volts
O carrier	- 117 volts

Assume a 1.0-volt drop between the batteries and fuse panels; 126 volts at the batteries would be the point at which the No. 12 service observing and No. 14 local test desk equipment would begin failing. Even if operation without these two systems were assumed, the SXS intertoll would begin failing as the voltage of the batteries dropped to 121 volts.

Therefore, from figure 2.4, a 66-cell, 412B, plant should be installed to meet our +130-volt power requirements. It's also apparent in reviewing BSP 800-610-165 that use of the 63-cell plant will primarily be limited to carrier repeater locations having no other major equipment entity installed (because of the relatively high low-failure voltage for non-repeater equipment).

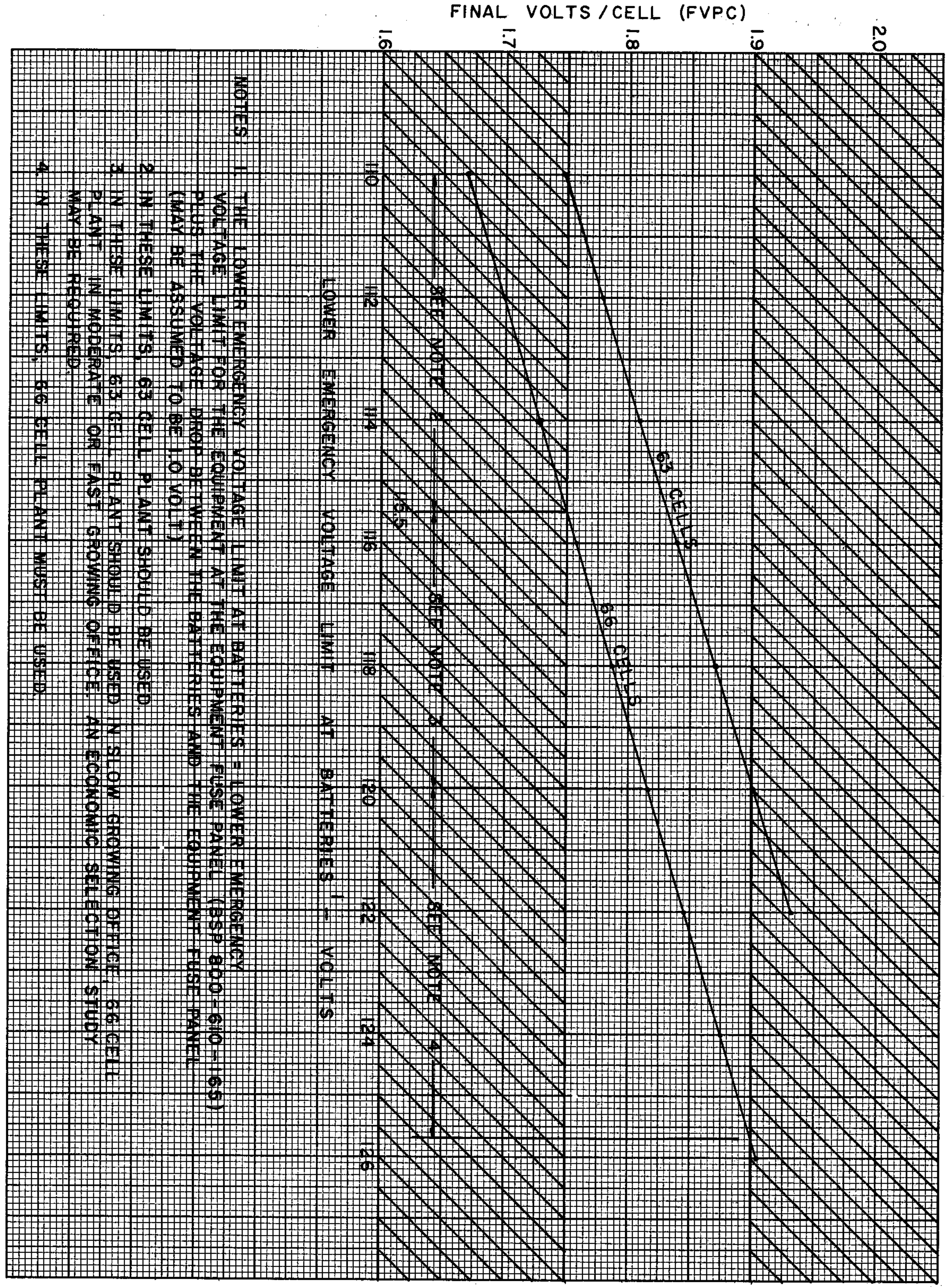


Figure 2.4 - 63 vs 66 Cell, 130 Volt Plant Selection Criteria

Using the four steps previously outlined, the appropriate new plants have been selected for application in the example. Modified, the principles encompassed in these four steps may be used in making any power decision requiring a selection among alternatives.

2.3 Table of Power Plant Engineering Considerations

Once a plant has been selected for a particular power application, certain decisions must be made by the Telephone Company engineer in selecting the proper equipment configurations. Many of these same decisions must be made each time an addition or change is made in the plant. Major plant characteristics, along with those areas requiring decisions on the part of the Telephone Company engineer, are summarized for most plants in figure 2.5. Items 1 thru 6 provide general information about each of the plants. Items 7 thru 24 list engineering decisions which, if an X appears in the appropriate column, may be required in properly engineering the plant. The reference section column indicates the section in this practice which may be referred to for more detailed information concerning the selection to be made. The following is an explanation of each of the items appearing in the "Table of Power Plant Engineering Considerations" (see figure 2.5) and the "Plant Reference Sheet" provided for each plant:

Item 1 - Plant (nominal) voltage(s): Shown are the nominal voltages at which the plant is designed to operate.

Item 2 - Operating voltage(s): The associated operating voltages are shown for each of the nominal voltages listed in item 1.

Items 3 thru 5 - Standard, A&M Only, Md'd: An X in the appropriate block indicates whether the plant is presently classified as standard, A&M only or manufacture discontinued. Standard plants are the only ones which can be ordered new for application in an office.

Item 6 - Plant Capacity: The largest available plant of a particular type is shown. This plant capacity in most cases reflects the capacity of the discharge equipment. However, in some cases, other equipment may be controlling. See the specific plant reference sheet for data on the available sizes and limiting equipment for each plant.

Item 7 - Select Plant Size or Capacity: When more than one size of a particular plant is available, the Western Electric engineer must be advised of the size required. Item 6 under the specific plant reference sheets indicates the choices available.

Item 8 - Select Plant and/or Operating Voltage: When more than one nominal and/or operating voltage is available in a plant, the Western Electric engineer must be advised of the proposed nominal and/or operating voltages.

Item 9 - Select Plant Operating Method: See the specific plant reference sheet for the 425B power plant.

Item 10 - Select Floor Plan Layout: The Telephone Company engineer is responsible for specifying the general layout and location of power plant equipment. See part B, section 2.4 for a complete discussion of those responsibilities.

ITEM NO.	ENGINEERING CONSIDERATION	REF. SECT.	105D	105E	110A	111A	301C	302A	302B	303A	326A	405A	410A	410B	411A	411B	412A	412B	413A	425A	425B	428A	702C	708A
1	GENERAL: PLANT (NOMINAL) VOLTAGE(S), VOLTS	—	-48	±24 48	-24 ±48	±24 48	-24 48	-24 48	-24 48	-24 48	±24 -48	±130	±130	±130	±130	±130	±130	±130	±52	NOTE 10	NOTE 11	±130	±130	±130
2	GENERAL: OPERATING VOLTAGE (S), VOLTS	—	NOTE 1	NOTE 2	NOTE 2	NOTE 2	NOTE 5	NOTE 5	NOTE 5	NOTE 5	NOTE 7	125-135	125-135	NOTE 8	125-135	125-135	125-135	125-135	130-156	NOTE 10	NOTE 11	110-140	125-135	125-135
3	GENERAL: STATUS: STANDARD	—		X		X			X	X	X				X	X	X	X	X		X			X
4	GENERAL: STATUS: A&M ONLY	—	X		X			X					X	X						X		X	X	
5	GENERAL: STATUS: MD'D	—					X					X												
6	GENERAL: PLANT CAPACITY	—	25	NOTE 3	640	NOTE 4	4,000	10,000	10,000	2,000	10,000	1.5	80	NOTE 9	120	120	120	120	500	NOTE 10	NOTE 11	40	1,000	1,000
7	SELECT PLANT SIZE OR CAPACITY	B,2.2			X	X	↑	X	X	X	X		X	X			X	X		X		X	X	
8	SELECT PLANT AND/OR OPERATING VOLTAGE	B,2.2	X	X	X	X		X	X				X	X	X	X	X	X	X	X		X	X	X
9	SELECT PLANT OPERATING METHOD	—																			X			
10	SELECT FLOOR PLAN LAYOUT	B,2.4	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	SPECIFY AC OPERATING VOLTAGES & PHASES	B,6.3	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X				X
12	SELECT SIZE & NUMBER OF BATTERIES	B,8.4	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13	SELECT SIZE OF CEMF CELLS	B,8.5	X	X	X	X						X	X	X			X	X						
14	SELECT SIZE & NUMBER OF CHARGE UNITS	B,6.2	X	X	X	X	SEE NOTE 6	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
15	SELECT SIZE & NUMBER OF DISCHARGE LOADS	B,6.7			X									X			X	X	X					
16	SELECT SIZE OF DISCHARGE METER & SHUNT	B,6.6			X			X	X	X	X		X	X						X		X	X	
17	SELECT TYPE OF MAIN CONTROL BOARD	B,6.6									X													
18	SELECT SIZE OF EMERGENCY CELL SWITCH	B,6.9						X	X	X													X	
19	SELECT SIZE OF BATTERY CHARGE FUSE	B,6.6						X	X														X	
20	SELECT SIZE OF BUSBAR: GENERATOR CHARGE OR CHARGE	B,6.8						X	X		X													
21	SELECT SIZE OF BUSBAR: DISCHARGE GROUND OR GROUND	B,6.8						X	X		X													
22	SELECT SIZE OF BUSBAR: BATTERY, BATTERY-OR BATTERY DISCHARGE	B,6.8						X	X		X													
23	SELECT SIZE OF BUSBAR: EMERGENCY CELL G-1 OR G-1 & 2	B,6.8						X	X															
24	SELECT SIZE OF BUSBAR: EMERGENCY CELL CHARGE	B,6.8					↓	X	X															

NOTES:

1. 44-52, 44-50/52
2. 22-26, 44-50/52, 44-50
3. NO FUNCTIONAL REASON TO LIMIT CAPACITY. 111A PLANT RECOMMENDED FOR LOADS EXCEEDING 30 AMPS.
4. 400A DISCHARGE WITH COUNTERCELL, 800A WITHOUT.
5. 22-26, 45-50
6. SEE PLANT REFERENCE SHEET FOR THE 301C POWER PLANT.
7. 22-26; FOR -48VOLTS, PLANT OPERATES AT 52 VOLTS SINCE THERE ARE NO EMERGENCY CELLS OR COUNTERCELLS IN THE PLANT.
8. 110-140 (63 CELLS); 125-135 (66+70 CELLS)
9. 63 CELLS-80 AMPS; 66 CELLS-80 AMPS; 70 CELLS-20 AMPS
10. 425A
11. 425B

	NOMINAL VOLTAGE	OPERATING VOLTAGE	CAPACITY AMPS
10. 425A	-12	9.9 - 11.5	1600
	-24	20 - 26	45
	+130	116 - 140	20
	+250	224 - 286	20
11. 425B	-12	12	22
	-24	20 - 26	1
	+130	138	30
	+250	116 - 140	0.35/CHANNEL

Figure 2.5 - Table of Power Plant Engineering Considerations

Item 11 - Specify AC Operating Voltages and Phases: Most charge units will operate on more than one type of AC input (either voltage and/or phases). The Telephone Company engineer must determine the nature of the AC source and advise the Western Electric engineer accordingly. Available options are covered in the 802 series BSP for the plant.

Item 12 - Select Size and Number of Batteries: The Telephone Company engineer is responsible for selecting the size and number of battery strings required. The number of emergency cells provided is a function of the plant installed; the size of the emergency cells provided will be identical to those of the batteries it is designed to supplement in the case of power failure. Procedures for battery sizing are provided in part B, section 7.4.

Item 13 - Select Size of CEMF Cells: The Telephone Company engineer is responsible for selecting the size CEMF cell(s) provided in any plant requiring countercell operation. Procedures for sizing countercells are outlined in part B, section 7.5.

Item 14 - Select Size and Number of Charge Units: The Telephone Company engineer is responsible for selecting and advising the Western Electric engineer of the size and number of charge units required. Part B, section 6.3 outlines criteria to be used in selecting charge units. See the <u>specific plant reference sheet</u> for the charge unit arrangements available for use with a particular plant.

Item 15 - Select Size and Number of Discharge Loads: Where applicable, the Telephone Company engineer is responsible for selecting the size and number of discharge loads. See the <u>specific plant reference sheet</u> for the appropriate plant.

Item 16 - Select Size of Discharge Meter and Shunt: The Telephone Company engineer is responsible for specifying the size of the discharge meter and shunt when a choice is available. See the <u>specific plant reference sheet</u> for the appropriate plant.

Item 17 - Select the Type of Main Control Board: See the <u>specific plant reference sheet</u> for the 326A power plant.

Item 18 - Select Size of Emergency Cell Switch: The Telephone Company engineer is responsible for specifying the size emergency cell switch to be installed. See the <u>plant reference sheet</u> for the appropriate plant. See part B, section 6.9 for procedures to be used in sizing emergency cell switches.

Item 19 - Select Size of Battery Charge Fuse: When installed in a plant, the size of the battery charge fuse is specified by the Telephone Company engineer. See the <u>plant reference sheet</u> for the appropriate plant.

Items 20 thru 24 - Selecting the Size of Busbar: The Telephone Company engineer is responsible for specifying the capacity of the various busbars. The Western Electric engineer is responsible for design of the busbar distribution system. Procedures for sizing busbar are outlined in part B, section 6.8. See the plant reference sheet for the appropriate plant.

PLANT REFERENCE SHEET - 105D POWER PLANT

Item 6 - Plant Capacity

The 105D's maximum charge capacity is 40 amps (initial 10-amp, plus two supplemental 15-amp rectifiers). Since one of the 15-amp rectifiers would be designated a maintenance spare, the maximum discharge load would be limited to 25 amps. A maximum of three rectifiers can be used in this plant, therefore, there would be a corresponding decrease in capacities if 15-amp rectifiers were not utilized.

Item 14 - Charge Units

The charge circuitry is capable of terminating only three rectifiers and is designed to handle 8-, 10-, 11- and 15-amp rectifiers, (the 15-amp rectifier is presently not available for order).

PLANT REFERENCE SHEET - 105E POWER PLANT

Item 6 - Plant Capacity

There is no functional reason to limit the capacity of the 105E plant; i.e., it is physically possible to terminate an unlimited number of rectifiers. However, for economic reasons, use of a 111A plant is recommended when the load exceeds 30 amps.

Item 14 - Charge Units

Designed for use with 11- or 15-amp rectifiers. (The 15-amp rectifier is presently not available for order).

PLANT REFERENCE SHEET - 110A POWER PLANT

Item 6 - Plant Capacity

The capacity of the plant may be either 120, 240, 520 or 640 amps depending on the discharge loads equipped. This stated capacity is the maximum theoretical discharge load which can be handled by the plant. The maximum loads which would actually be placed on the plants would be 90, 210, 420 and 540 amps respectively (theoretical capacity less maintenance spare).

Item 14 - Charge Units

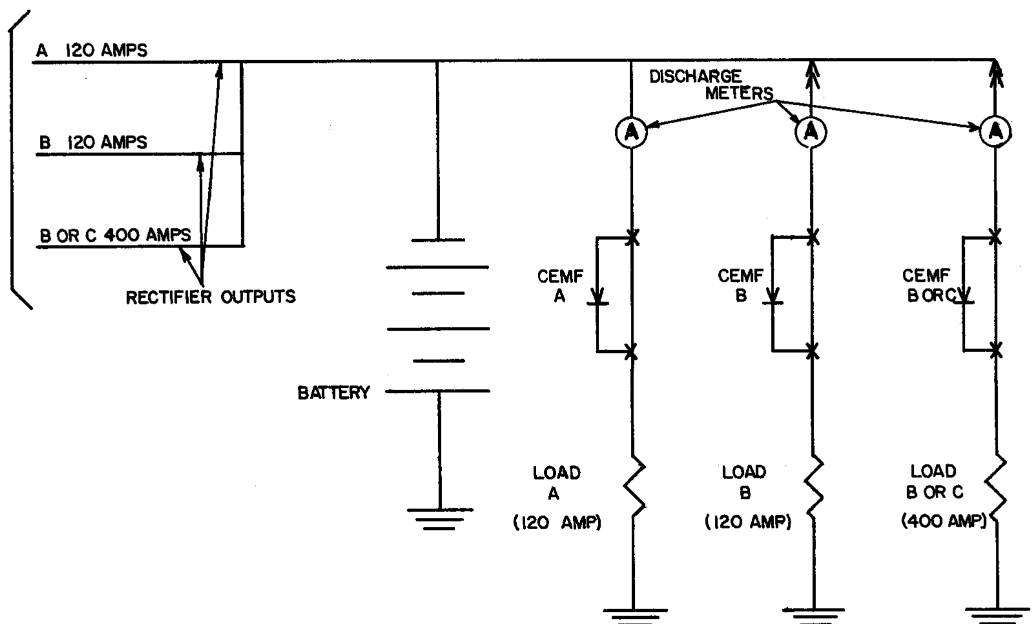
Discharge loads A & B (see item 15) can be equipped with 30-amp rectifiers when the load capacity is 120 or 240 amps. Load B may be equipped with 30- or 100- amp rectifiers if the plant capacity is 520 amps. Discharge load C, if provided, can be equipped with either 30- or 100-amp rectifiers.

Item 15 - Discharge Loads

The 110A plant discharge loads are segregated into one to three separate loads, designated A, B and C (see figure on next page). Load A is normally equipped with four 30-amp rectifiers. Load B (which can no longer be ordered new) is also normally equipped with four 30-amp rectifiers. Load C can be equipped with a maximum of four 30- or 100-amp rectifiers. As can be seen in the figure, the outputs of the rectifiers, regardless of load, are shared by all loads. Each load is equipped with its own CEMF cell and discharge meter. The Telephone Company engineer is responsible for determining what loads will be equipped and what size rectifiers will be provided.

Item 16 - Discharge Meter and Shunt

Loads A and B (120-amp capacity) may be equipped with either a 75- or 150-amp discharge meter and shunt. The 150-amp arrangement should always be provided. Load B (in a 520-amp plant) or load C is always equipped with a 500-amp meter.



Typical 110A Plant - A, B, and C Loads

PLANT REFERENCE SHEET - 111A POWER PLANT

Item 6 - Plant Capacity

Various plant arrangements are available for both 24- and 48-volt operation and are outlined in BSP 802-659-160. Countercell operation limits plant capacity to 400 amps (for instance, when 50-volt operation is required in a 48-volt plant); otherwise, the capacity is 800 amps. A second plant may be provided as a separate, parallel load.

Item 14 - Charge Units

The 24-volt plants are available with 11-, 15-, 30- or 100-amp rectifiers. The 48-volt plants are available with 30- or 100-amp rectifiers. See BSP 802-659-160 for the rectifiers available with each plant arrangement (the 15-amp rectifier is presently not available for order).

PLANT REFERENCE SHEET - 301C POWER PLANT

Item 6 - Plant Capacity

The 301C plant has been rated manufacture discontinued since 1962. The capacity of the 301C plant was 4,000 amps; however, many of the original 301C plants have been modified for 6,000- and 10,000-amp operation using 302-type equipment. Any further modifications or enlargements of existing 301C plants must be made using 302-type equipment. Details of the equipment arrangements in the 301C plant are outlined in AA367.302.

PLANT REFERENCE SHEET - 302A POWER PLANT

Item 6 - Plant Capacity

The original 302A plant had a capacity of 10,000 amps and was designed to function with both motor-generator sets and rectifiers. Presently only those plants (1) having less than a 4,000-amp emergency cell switch (600-, 1200- or 2000-amp) or (2) having a 4,000-, 6,000- or 10,000-amp switch but arranged for sequential operation (see part B, section 6.3) are designated 302A. Existing 302A plants can be expanded to increased capacity using 302B equipment.

Item 14 - Charge Units

The 302A power plant may be equipped with various sizes of motor-generator sets and 100- or 400-amp rectifiers.

Item 16 - Discharge Meter and Shunt

Various discharge meters and shunts are available with each size of emergency cell switch. The discharge meter and shunt should normally be sized to match the emergency cell switch. However, if the load is small compared to the full scale reading of the meter, a smaller meter may be warranted.

Item 18 - Emergency Cell Switch

Emergency cell switches are available in 600-(A&M), 1200-(A&M), 2000-(Std.), 4000-(Std.), 6000-(Std.) and 10,000-amp (Std.) sizes.

Item 19 - Battery Charge Fuse

Older plants may have battery charge fuses which are designed to protect the charge leads. The charge fuses are available in various sizes (depending on the size emergency cell switch installed) and should be capable of handling the total output of the installed charge units. The charge fuses are no longer provided on new plants and, if possible, are being removed from existing plants when they are modified for increased capacity. The battery charge fuse must be left in place if motor-generator sets are being utilized in the plant since the motor-generator sets are not equipped with internal charge lead protection.

Item 20 - Bus Bars

The following bus bars must be sized:

Generator Charge

Ground or Charge Ground

Battery Charge

Battery -

Emergency Cell G-1

Emergency Cell G-1 & 2

Emergency Cell Charge

Discharge Ground

PLANT REFERENCE SHEET - 302B POWER PLANT

Item 6 - Plant Capacity

To be designated a 302B, a plant must have a 4,000-amp or larger emergency cell switch and be arranged for non-sequential operation (see part B, section 6.3). The 302B plant is available in -24, -48 or combined 24 and 48-volt arrangements and has a maximum capacity of 10,000 amps.

Item 14 - Charge Units

Charge units are available in 400-, 800- and 1600-amp capacities.

Item 16 - Discharge Meter and Shunt

Various discharge meters and shunts are available with each size of emergency cell switch. The discharge meter and shunt should normally be sized to match the emergency cell switch. However, if the load is small compared to the full scale reading of the meter, a smaller or dual-range meter may be warranted.

Item 18 - Emergency Cell Switch

Emergency cell switches for the 302B plant are available in 4,000-, 6,000- and 10,000-amp capacities.

Item 19 - Battery Charge Fuse

Older plants may have battery charge fuses which are designed to protect the charge leads. The charge fuses are available in various sizes (depending on the size emergency cell switch installed) and should be capable of handling the total output of the installed charge units. The charge fuses are no longer provided on new plants and, if possible, are being removed from existing plants when they are modified for increased capacity. The battery charge fuse must be left in place if motor-generator sets are being utilized in the plant since the motor-generator sets are not equipped with internal charge lead protection.

Items 20 thru 24 - Bus Bars

The following bus bars must be sized:

Generator Charge

Ground

Battery or battery -

Emergency Cell G-1

Emergency Cell G-1 & 2

Emergency Cell Charge

PLANT REFERENCE SHEET - 303A POWER PLANT

Item 6 - Plant Capacity

The capacity of the 303A plant is discharge limited and is a function of the size of emergency cell switch installed. Two sizes of the 303A plant are available: 1,000 and 2,000 amps. Because of the relatively minor cost difference between the two plants, new 303A plants should be provided with a 2,000-amp capacity.

Item 14 - Charge Units

The 24-volt plant is designed to use either 100- or 400-amp rectifiers while the 48 volt plant will handle 100-, 400- and 800-amp rectifiers. A maximum of six rectifier bays can be handled by the control circuitry (6 400- or 800-amp rectifiers or 24 100-amp rectifiers if provided in a four-pack arrangement).

Item 16 - Discharge Meter and Shunt

A 1,250-amp discharge meter is provided with the 1,000-amp plant; a 2,500-amp meter is provided with the 2,000-amp plant.

Item 18 - Emergency Cell Switch

A 1,000-amp emergency cell switch is provided with the 1,000-amp plant, a 2,000-amp switch with the 2,000-amp plant. As mentioned above, the 2,000-amp switch should be provided initially with all new plants. Upon failure of the commercial power supply, both groups of emergency cells are connected to the discharge circuit in parallel. If the power failure continues, the two emergency cells are later connected in series. This arrangement conserves the capacity of the cells and equalizes the deterioration of the cells.

PLANT REFERENCE SHEET - 326A POWER PLANT

Item 6 - Plant Capacity

The 326A plant may be obtained in 8,000- and 10,000-amp capacities for combined +24 and -48-volt operation. It is also available as a plant in combinations of 2000-, 4000- and 6000-amp capacities to satisfy individual +24 and -48 volt requirements. The stated capacity is the maximum discharge load the plant is capable of handling. The 326A plant does not employ an emergency cell switch or emergency cells.

Item 14 - Charge Units

The 326A plant is designed to function with 100-, 400- or 800-amp rectifiers. Note 111 of SD-81861-01 and BSP 802-727-150 place an additional restriction on the selection of rectifier sizes; however, this restriction need not be adhered to if a maintenance spare rectifier is provided.

Item 16 - Discharge Meter and Shunt

See discussion under item 17.

Item 17 - Type Main Control Board

The main control board for the 326A plant is available in the following sizes: 2000-, 4000-, 6000-, 8000- and 10,000-amp capacities. Since the plant is designed for use in No. 1 ESS offices, the main control board may be arranged for both +24 and -48 volts. The 8000- and 10,000-amp plants are designed for combined +24 and -48 volt operation. The 2000-, 4000- and 6000-amp plants may be arranged for either combined or individual operation. Economics indicate that if an 8000-amp main control board is required (using same criteria as that for sizing emergency cell switch), then a 10,000-amp bay should be provided with an 8000-amp bus bar. If a 2000- or 4000-amp bay is required, then a 6000-amp bay and smaller bus bar should be provided. All main control bays are equipped with dual range (full and half scale) meters. The responsibility for specifying the size main control board and size bus bar is the Telephone Company's engineer.

Items 20 thru 24 - Bus Bars

The following bus bars will be sized by the Western Electric engineer to match the capacity of the main control board unless otherwise advised by the Telephone Company engineer:

Charge Ground

Discharge Ground

-48V charge

+24V charge

-48V discharge

+24V discharge

In addition, the 2-, 4- and 6000-amp plants may be equipped with either copper or aluminum bus (see part B, section 6.7). The Telephone Company engineer is responsible for specifying the type bus bar to be installed.

PLANT REFERENCE SHEET - 405A POWER PLANT

Item 6 - Plant Capacity

The 405A plant (either positive or negative 130 volts) employs one 2-amp rectifier which is capable of handling fixed or variable loads from 0.1 to 1.5 amps.

PLANT REFERENCE SHEET - 410A POWER PLANT

Item 6 - Plant Capacity

The capacity of the original 410A plant was 25 amps but the plant can be modified for 40 amps. A second 40-amp discharge load may be added (using 411 or 412 type equipment) increasing the plant capacity to 80 amps. The size of the discharge meter shunt limits the discharge capacity of the plant.

Item 14 - Charge Units

The 410A plant may employ 8-, 10-, 24- or 30-amp rectifiers, although regulation is limited when the larger rectifiers are used (see BSP 802-754-150, Table A). Load on 8-amp rectifiers should be limited to 5 amps to permit recharge of batteries after power failure.

Item 16 - Discharge Meter and Shunt

The 25-amp plant is equipped with a 30-amp meter and shunt. The 40-amp plant is equipped with a 50-amp meter and shunt.

PLANT REFERENCE SHEET - 410B POWER PLANT

Item 6 - Plant Capacity

The capacity of the 63-cell plant is 80 amps. The 66-cell plant may be arranged for an 80-amp capacity by using two 40-amp loads. The 70-cell plant, which is designed for L carrier and TH radio applications, can handle up to a 20-amp load. These capacities can actually be increased (within the limits of the discharge control circuits) with a corresponding increase in time for recharge.

Item 14 - Charge Units

The 63- and 66-cell plants are designed to function with 8-, 10-, 24- or 30-amp rectifiers. The 70 cell plant utilizes only 8- or 10-amp rectifiers.

Item 15 - Discharge Loads

The 66-cell plant can be arranged for two discharge loads, each having a capacity of 40 amps.

Item 16 - Discharge Meter and Shunt

63-cell plant: May be equipped with either a 50- or 100-amp meter and shunt.

66-cell plant: Each CEMF control unit is equipped with a load meter (50 amps is standard).

70-cell plant: Equipped with 30-amp meter and shunt.

PLANT REFERENCE SHEET - 411A POWER PLANT

Item 6 - Plant Capacity

The 411A is a 63-cell, duct-type plant designed to provide a maximum of 180 amps of charge and 120 amps of discharge capacity, thereby providing 60 amps of recharge capacity. See part B, section 2.2 for a discussion of 411A and 411B plants.

Item 14 - Charge Units

The plant is designed to handle a maximum of six 10- or 30-amp rectifiers.

PLANT REFERENCE SHEET - 411B POWER PLANT

Item 6 - Plant Capacity

The 411B is a 63-cell, cabinet-type plant designed to provide a maximum of 180 amps of charge and 120 amps of discharge capacity, thereby providing 60 amps of recharge capacity. See part B, section 2.2 for a discussion of the selection of 411A and 411B plants.

Item 14 - Charge Units

The 411B plant is designed to handle a maximum of six 10- or 30-amp rectifiers.

PLANT REFERENCE SHEET - 412A POWER PLANT

Item 6 - Plant Capacity

The 412A, 66-cell, duct-type plant is designed for a maximum discharge capacity of 120 amps and a charge capacity of 180 amps, thereby providing 60 amps for recharge. The discharge capacity is available in one to three 40-amp discharge loads. See part B, section 2.2 for a discussion of the selection between 412A and 412B plants.

Item 14 - Charge Units

The 412A plant is designed to handle a maximum of six 10- or 30-amp rectifiers.

Item 15 - Discharge Loads

The 412A plant may be equipped with from one to three 40-amp discharge loads, each having a 50-amp meter and shunt.

PLANT REFERENCE SHEET - 412B POWER PLANT

Item 6 - Plant Capacity

The 412B is a 66-cell, cabinet-type plant designed for a maximum discharge capacity of 120 amps and a charge capacity of 180 amps, thereby providing 60 amps for recharge. The discharge capacity is available in one to three 40-amp discharge loads. See part B, section 2.2 for a discussion of the selection between 412A and 412B plants.

Item 14 - Charge Units

The 412B plant is designed to handle a maximum of six 10- or 30-amp rectifiers.

Item 15 - Discharge Loads

The 412B plant may be equipped with from one to three 40-amp discharge loads, each having a 50-amp meter and shunt.

PLANT REFERENCE SHEET - 413A POWER PLANT

Item 6 - Plant Capacity

The 413A is a positive or negative 152-volt plant which may be equipped for a maximum of five 100-amp rectifiers. A diagram of typical plant arrangements is shown in the AT&T Power Engineering Manual, section 4, supplement C.

When used with the 505D (L3 carrier) and 508A (TH radio) plants, the 413A plant is used to float the batteries (70 cells) which are used to drive DC motors in the event of a commercial power failure. The 413A plant's charge capacity must also be sufficient to recharge the plant's batteries after a commercial power failure.

When used with the 520A (TH radio) and 521A (L3 carrier) plants, the 413A must be capable of handling the input to the DC-AC inverters in addition to being able to float and recharge the batteries.

Item 14 - Charge Units

The 413A plant is designed to handle a maximum of five 100-amp rectifiers.

Item 15 - Discharge Loads

A second 500-amp load or plant may be parallelled with the first plant. The two plants are tied common at the charge fuse through a 600-amp fuse.

PLANT REFERENCE SHEET - 425A POWER PLANT

Item 6 - Plant Capacity

The 425A plant provides the various voltages required for operation of TD-2 equipment (see BSP 802-759-153, figure 2, for a system block diagram). Requirements for -24 volts are included although not provided as part of the coded plant. The capacities of the plant are as follows (standard unless noted otherwise): -12-volt, 1600 amps; -24-volt, 45 amps; +130-volts (A&M), 20 amps (an additional 20-amp load supplies the 250-volt plant); +250 volts, 20 amps.

Item 14 - Charge Units

The following charge unit arrangements are available in the various voltages:

-12V (Std.) : 1600 amps, 5 - 400-amp rectifiers

(A&M) 800 amps, 5 - 200-amp or 3 - 400-amp rectifiers

-24V (Std.) : 45 amps, 3 - 15-amp rectifiers or separate -24-volt plant (the 15-amp rectifiers are presently not available for order)

+130V (A&M) : 20 amps, 4 - 8-amp rectifiers or separate +130-volt plant

+250V (A&M) : 20 amps, 4 - 8-amp rectifiers

(Std.) : 20 amps, 5 - 5-amp converters

Item 16 - Discharge Meter and Shunt

The following discharge meter arrangements are available:

-12V : 800 amps (A&M), 400-, 800-, 1000-amp meter; 1600 amps (Std.), 1000- and 2000-amp meter.

+130V : 20 amps (A&M), 15- or 30-amp meter

PLANT REFERENCE SHEET - 425B POWER PLANT

Item 6 - Plant Capacity

The 425B plant is designed to provide power for secondary route TD-2 stations. Two arrangements are available: with or without battery reserve. Since the arrangement with battery reserve should always be utilized, the following capacities are for that arrangement:

- -12V : 22 amps per unit, 1 unit required for each TD-2 channel
- -24V : 1 amp
- +130V : 30 amps
- +250V : 0.35 amp per unit, 1 unit required for each TD-2 channel

A block diagram of the battery arrangement is shown in figure 2, BSP 802-759-160.

Item 9 - Plant Operating Method

The 425B plant may be arranged as a power supply with or without battery reserve. The arrangement with battery reserve should always be utilized.

Item 14 - Charge Units

- -12V : J86450B power supply
- -24V : 1 - 1-amp rectifier
- +130V : 4 - 8-amp rectifiers
- +250V : J86450B power supply

PLANT REFERENCE SHEET - 426A POWER PLANT

Item 6 - Plant Capacity

The 426A plant can be equipped with a maximum of eight 8- or 10-amp rectifiers. The discharge capacity is limited to 40 amps (5 amps per rectifier) to permit recharge of the batteries after commercial power failure.

Item 14 - Charge Units

The 426A plant is designed to handle a maximum of eight 8- or 10-amp rectifiers.

Item 16 - Discharge Meter and Shunt

The 426A plant may be equipped with either a 15- or 50-amp discharge meter and shunt.

PLANT REFERENCE SHEET - 702C POWER PLANT

Item 6 - Plant Capacity

The capacity of the 702C plant is limited by the size of the emergency cell switch installed. The plant can be equipped for up to 1,000 amps of discharge (see item 18).

Item 14 - Charge Units

The 702C plant was designed for use with various sizes of motor-generator sets and 100-amp rectifiers.

Item 16 - Discharge Meter and Shunt

Discharge meters are available in the following sizes: 250, 500, 1000 and 1500 amps.

Item 18 - Emergency Cell Switch

Emergency cell switch sizes: 200, 500, 600 and 1000 amps.

Item 19 - Battery Charge Fuse

Battery charge fuses, when provided, are available in the following sizes: 300, 400, 650, 800, 1000 and 1500 amps.

PLANT REFERENCE SHEET - 708A POWER PLANT

Item 6 - Plant Capacity

The capacity of the 708A plant is limited by the size of emergency cell switch installed. Only one size, a 1000-amp switch, is available. A 1500-amp discharge meter is provided with this plant.

Item 14 - Charge Units

The 708A plant may be equipped with up to twelve 100-amp rectifiers.

2.4 Floor Plan Layout Considerations

In the process of planning a new building or building addition, the Telephone Company Architectural planning engineer selects the general location of the power plant equipment. The general location of the power equipment must be determined at that time (rather than when the power plant equipment is actually engineered) because (1) certain power equipment (as AC distribution equipment) and associated peripheral equipment (as exhaust louvers and piping for emergency engines) are provided as part of the building work associated with the new building or addition, and (2) the location and floor loading of the power equipment must be considered in the structural design of the new building or addition.

In most cases, the Architectural planning engineer will draft the preliminary building floor plans and submit them to the equipment engineering groups (and others) for their suggestions and comments. If the layout of the power equipment is satisfactory to the equipment engineer, the proposed layout will later be incorporated into the floor plan drawings submitted to Western Electric engineering for detailed engineering. During preliminary analysis of the Telephone Company specification and proposed floor plan layout, the Western Electric engineer will prepare a preliminary, detailed floor plan which will be forwarded to the Telephone Company engineer for his approval. Any changes or suggestions by the Telephone Company engineer will be included in the final Western Electric floor plan layout.

In specifying the location of the power plant equipment, the Architectural planning engineer will consider various factors. In buildings having no basements, the plants should be located away from the growing end of the building and the distributing frames. This usually limits the number of desirable locations available for installing the power plants.

In smaller multi-story buildings (up to three floors) having basements, the power equipment will almost always be located in the basement. In this case, the power room should be located to permit growth of the power equipment into the basement of any future building additions.

In large multi-story buildings, the amount of mechanical equipment located in the basement will usually limit the amount of power equipment that can also be located there. In addition, considerable savings will result when a power plant is located near the center of the ultimate number of floors it will serve. Since power equipment is generally much heavier than other telephone equipment, location of those upper-floor power plants must be considered in the original structural design of the building or steps must be taken to reinforce the structure when, at a later date, it is decided to locate power equipment in a location not designed for it.

The main AC switchboard (when required) will usually be located in the basement. It will normally be installed in close proximity to the transformer banks serving the building and will be located to avoid running AC leads through the cable vault (to minimize induction problems).

There are two occasions when it is imperative that the Telephone Company equipment engineer verify with the Architectural engineer that the building structure is adequate for the power equipment being engineered:

(1) When an emergency engine is being located on the roof of an existing structure.

(2) When it is proposed to locate power equipment in a building bay not originally designed for it, especially if the proposed location is not in the basement of the building.

Normally a power equipment room is not air conditioned. However, in some cases ventilating equipment is not adequate to maintain a reasonable power room temperature and air conditioning may be provided. Ambient operating temperatures for a particular piece of equipment can normally be found in the appropriate BSP, SD or power data sheet.

Typical floor plan layouts of various power equipment items are included in section 8 of the Floor Plan Data book and in section 7 of the AT&T Power Engineering Manual. Additional information which may be used in laying out floor plans can be found in the BSP's, J drawings and ED drawings covering a particular plant. Other floor plan considerations pertaining to specific portions of the power plant are covered in the appropriate section of Part B of this practice.

PART B - SECTION 3.0
SWX-XXXX-550-G DRAWING

3.1 Purpose

The purpose of the SWX-XXXX-550-G drawing is to:

1) Provide the Telephone Company equipment engineering groups with a guide to be used in the engineering and administration of central office power plants;
2) provide the Telephone Company Plant Department with information which can be used to quickly check the adequacy of the capacities of the presently installed major components of power equipment;
3) provide Western Electric engineering with sufficient information to insure proper detailed engineering of the power plant equipment.

3.2 General Layout

Two different predrafted formats of the SWX-XXXX-550-G drawing are available: "Sheet 1" and "Sheet 2".

As can be seen in figure 3.1, the "Sheet 1" drawing provides room for recording data on two power plants (parts I thru III) and general information pertaining to an office (parts IV thru VII). At some point in time, a "Sheet 1" drawing will be issued for each central office location or base number having installed power equipment.

The "Sheet 2" drawing (see figure 3.2) provides sufficient space for recording information about three power plants. The "Sheet 2" drawing(s) should be used to record information about the the third and any subsequent plants installed under a particular base number.

3.3 Reference Sections

Details for completing the SWX-XXXX-550-G drawing are outlined in the appropriate sections of this practice as follows:

Drawing Part	Reference Section
I	Part B, Section 3.5
II A-D	Part B, Section 4.7
III A-C	Part B, Section 7.7
III D,E	Part B, Section 6.11
IV	Part B, Section 8.18
V	Part B, Section 5.5
VI	Part B, Section 9.4
VII	Part B, Section 10.10

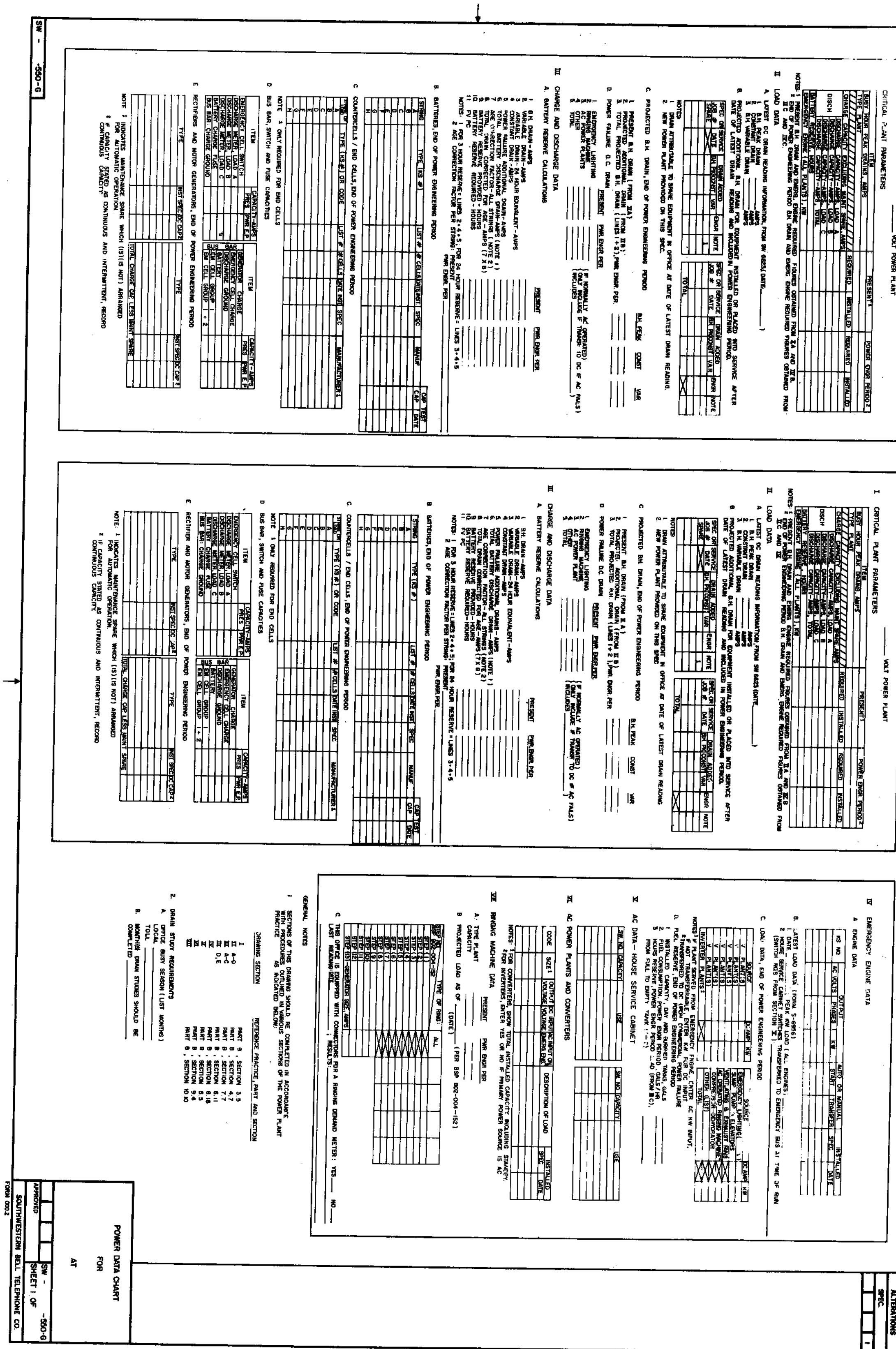


Figure 3.1 - SWX-XXXX-550-G Drawing, Sheet 1

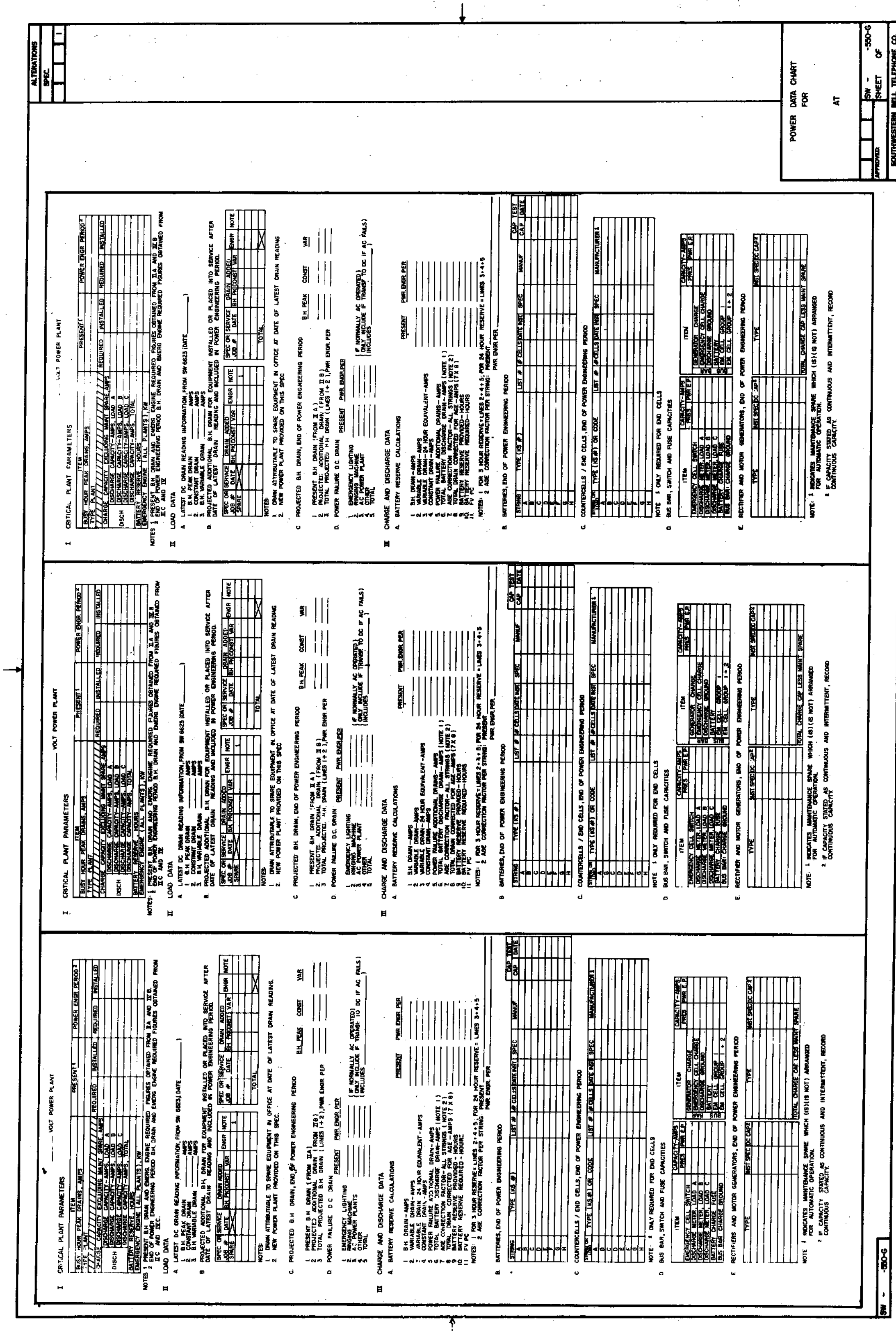


Figure 3.2 - SWX-XXXX-550-G Drawing, Sheet 2

3.4 Requirements for Completion, Update and Distribution

Generally, the SWX-XXXX-550-G drawing will be issued initially in conjunction with the next major growth job engineered at a location. Areas may establish local policies regarding targets for completion and items to be included in the initial issue of the drawing.

The SWX-XXXX-550-G should be updated and reissued any time a change is detected in any of the information recorded on it. Generally, the drawing will be reissued and distributed in conjunction with issuance of a Telephone Company specification covering the addition or removal of equipment in an office. In some cases, however, update and/or distribution may be required when no specification is being written.

Distribution in conjunction with issuance of a Telephone Company specification should be made using established office form No. 6 procedures. Distribution should at least be made (but not limited to the following:

- Wire chief or chief switchman having responsibility for the office
- Appropriate Division Plant Superintendent's organization
- Appropriate Service Manager of the Western Electric Company

3.5 Critical Plant Parameters

Part I of the SWX-XXXX-550-G drawing is designed to permit a quick check of the service - affecting capacities of the plant. The critical parameter section may also be used to facilitate checking by the Engineering Department of plant capacities upon receipt of Annual DC Power Drain Studies (Form SW6623) and/or Emergency Engine Load Test Results (Form S-6956). In addition, this part may be used by local plant personnel to monitor the status of the plants between scheduled power studies.

The various entries required in Part I of the drawing should be made in accordance with the following (numbers shown refer to corresponding entries as shown in figure 3.3):

(1) From IIA.

(2) Installed plant (105E, 303A, etc.) on date of latest drawing issue.

(3) Same as peak busy-hour drain shown in (1).

(4) - (7) Where drain readings are available by loads, record under appropriate loads. Total under (7) should be the same as busy-hour peak drain shown in (1) plus power failure drain shown in II D. If plant is equipped with only one load, the entry should be made in (7) .

(8) Usually 3 or 24 hours unless another agreement has been reached between Plant and Engineering. Record 3 hours if an emergency engine is installed in the office. Record 24 hours if no emergency engine is installed in the office.

(9) From IVB.

(10) From IIIE. Should not include rectifiers scheduled to be installed after the latest drawing issue date.

(11) - (14) Enter the present (as of latest drawing issue date) capacities of the discharge loads. If the

plant is equipped with only one load, reflect this capacity in (14).

(15) From IIIA.

(16) From IVA. Record the total capacities of all engines installed as of the latest drawing issue date.

(17) From IIC.

(18) Record the type plant to be installed at the end of the power engineering period.

(19) Same as shown in (17).

(20) - (23) In multiple load plants, item (23) should be the same as that shown in (17) plus power failure drain shown in II D. An estimate of required drain distribution should be made in (20) - (22). In single load plants an entry is only required in (23).

(24) See explanation under (8).

(25) Total KW from IIIC.

(26) Total figure from IIIE.

(27) - (30) Enter the capacities of the discharge loads for the end of power engineering period. If the plant is equipped with only one load, reflect this capacity in (30).

(31) From IIIA.

(32) From IVA. Record the total capacities of all engines installed at the end of the power engineering period.

As mentioned previously, the "Critical Plant Parameters" section may be used by the Engineering Department to check the adequacy of installed plant capacities. Flow charts for a typical verification of capacities upon receipt of an Annual DC Power Drain Study (Form SW6623) and/or an Emergency Engine Load Test Result (Form S6956) are shown in figures 3.4 and 3.5 respectively. Circled numbers refer to items shown in figure 3.3. The process outlined in figure 3.5 can also be used to check capacities of gas turbine installations as reported on form E-5697. The process of comparing present loads and drains against engineered load assumptions or capacities can be modified to permit referral to an engineer at any predetermined load. For example, in figure 3.5, it may be decided that an emergency engine load test should be referred to an engineer each time the peak load exceeds 80% of the installed engine capacity.

3.6 Office Busy Seasons

BSP section 157-601-902 SW, which covers requirements for completing the Annual Power Drain Study (SW6623) for an office, states that this annual study should be made during the busy season. However, in offices having both toll and local switching machines operating from the same power plant, two separate busy season may be experienced. In that case, two drain studies would be required, one during the local busy season and one during the toll busy season. Of course, more frequent studies may be made if (1) pen recording equipment has been installed, (2) the plant is in an attended office or (3) special circumstances warrant them.

The toll and/or local switching busy seasons should be determined (with the assistance of

-48 VOLT POWER PLANT

I CRITICAL PLANT PARAMETERS

ITEM		PRESENT[1]		POWER ENGR PERIOD[2]	
BUSY HOUR PEAK DRAINS, AMPS		① 160		⑰ 220	
TYPE PLANT		② 110A		⑱ 110A	
		REQUIRED	INSTALLED	REQUIRED	INSTALLED
CHARGE CAPACITY EXCLUDING MAINT SPARE, AMPS		③ 160	⑩ 180	⑲ 220	㉖ 340
DISCH	DISCHARGE CAPACITY-AMPS, LOAD A	④ 70	⑪ 120	⑳ 70	㉗ 120
	DISCHARGE CAPACITY-AMPS, LOAD B	⑤ 90	⑫ 120	㉑ 90	㉘ 120
	DISCHARGE CAPACITY-AMPS, LOAD C	⑥ —	⑬ —	㉒ 60	㉙ 400
	DISCHARGE CAPACITY-AMPS, TOTAL	⑦ 160	⑭ 240	㉓ 220	㉚ 640
BATTERY RESERVE, HOURS		⑧ 3.0	⑮ 2.7	㉔ 3.0	㉛ 7.0
EMERGENCY ENGINE (ALL PLANTS), KW		⑨ 44.2	⑯ 60	㉕ 51.45	㉜ 60

NOTES: 1 PRESENT B.H. DRAIN AND EMERG. ENGINE REQUIRED FIGURES OBTAINED FROM IIA AND IVB.
2 END OF POWER ENGINEERING PERIOD B.H. DRAIN AND EMERG. ENGINE REQUIRED FIGURES OBTAINED FROM IIC AND IVC.

Figure 3.3 - Critical Plant Parameters, SWX-XXXX-550-G Drawing

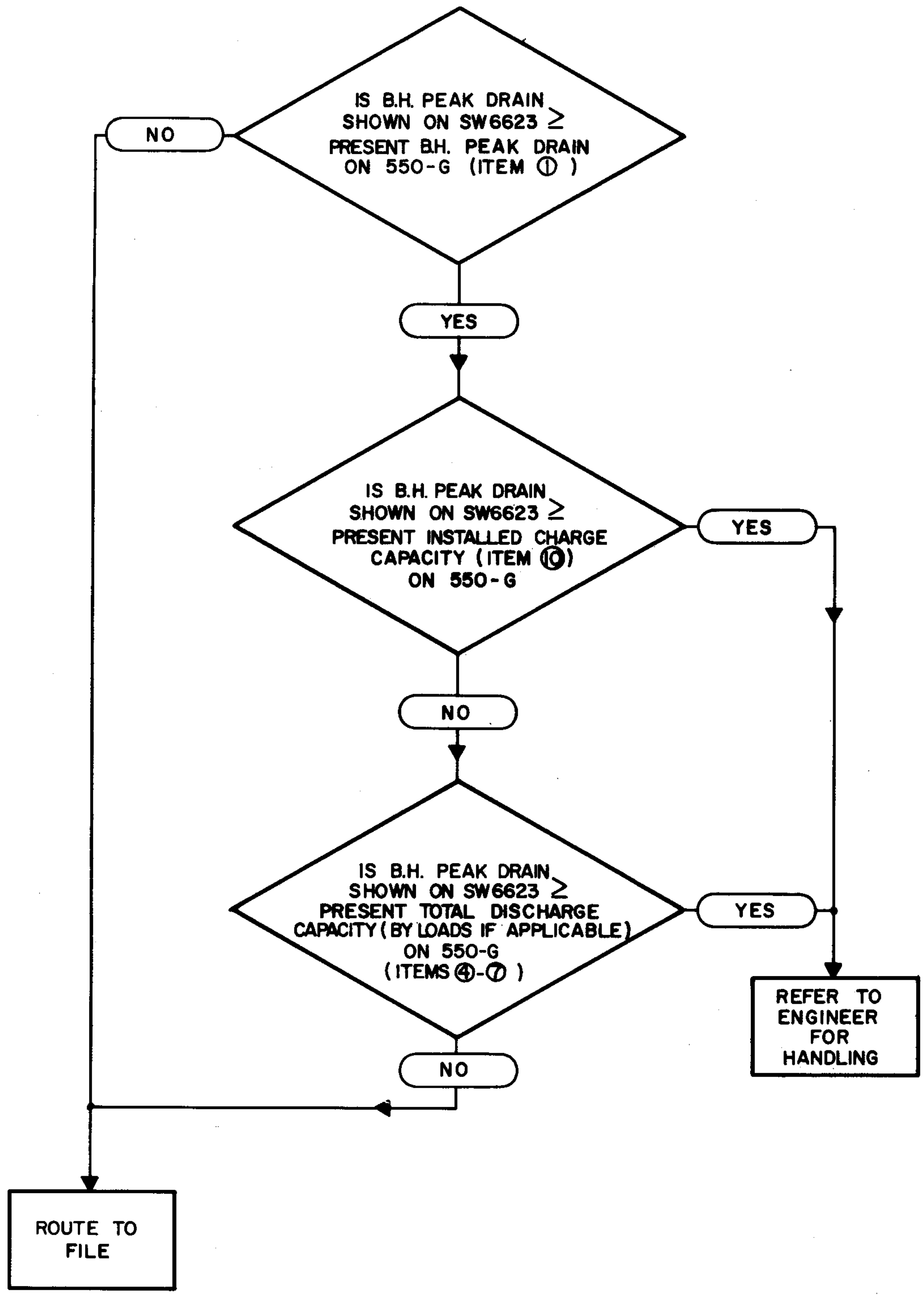


Figure 3.4 - Flow Chart - Verification of Plant Capacities Upon Receipt of an Annual D.C. Power Drain Study, Form SW 6623

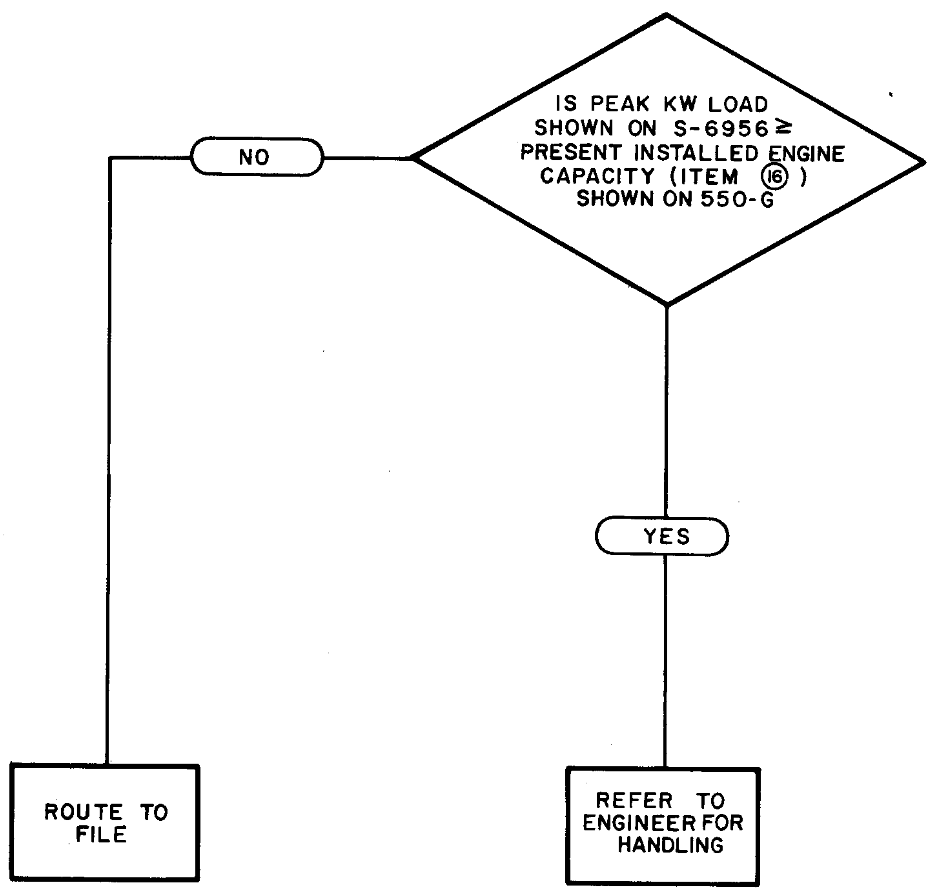


Figure 3.5 - Flow Chart - Verification of Plant Capacities Upon Receipt of an Emergency Engine Load Test Result, Form S-6956

Traffic) at the time of initial issue of the SWX-XXXX-550-G drawing. In those locations having no switching equipment installed, the power drain study may be completed during any month of the year. The Telephone Company equipment engineer is responsible for establishing, with the Plant Department, the specific month in which drain studies will be accomplished. This information should be recorded in note 2B of the "General Notes" section of the SWX-XXXX-550-G drawing and will serve as a guide for the local plant representative in completing his studies.

Emergency engine load tests for diesels (recorded on form S6956) should also be made during the office busy season(s). For gas turbines, one of the three-month, full-load runs should be made during the busy hour of the office busy season (recorded on form E-5697).

PART B - SECTION 4.0

DRAIN DATA

4.1 Introduction

Power plant engineering is only as good as the quality of the drain data that is used as the basis for sizing the emergency engine,[1] rectifiers, batteries, charging circuit, and discharge circuit. Therefore, it is vitally important to have a basic understanding of how to:

1. Obtain, interpret and apply drain readings in monitoring an existing power plant.
2. Estimate and apply the drain for idle equipment and equipment being engineered (additions or new).
3. Project drain requirements for use in long range planning.

This section covers the procedures that are generally used to accomplish these results.

4.2 Existing Power Plant

The present discharge drain readings are the first item that must be obtained when investigating the adequacy of an existing plant. These drain readings can be obtained verbally or in writing from the Plant Department. Except in rare or emergency conditions, the data should be written and supplied by the Plant Department under normal routines as outlined in this practice.

In those cases where the information is obtained verbally, the date obtained, date and time of readings, and name of person providing the readings should be recorded on the drain sheet that is included in the estimate, specification, file, etc., with a notation that the information was obtained verbally. The engineer obtaining the data should also record his name.

The discharge current drain readings for the various power plants in an office or repeater station should be recorded periodically on Form SW6623 (previously Form S-6864), figure 4.1, by the Plant Department (see BSP 157-601-902SW) and forwarded to the Engineering Department, where they will be routed to the appropriate Equipment Engineers for review (see part B, section 3.5). After this review they shall be forwarded to the Engineering library and filed in "Power Drain Record" books.

Twenty-four hour discharge drain readings for <u>variable load</u> plants may be obtained using a recording meter similar to the General Electric CF-2 outlined in BSP 171-122-301. The portable General Electric unit is designed for use with a 50 millivolt shunt. A bay mounted unit, the Rustrak Model 288, is available for mounting in the power board. This unit is also designed to function with a 50 millivolt shunt. When recording meters are employed, the results of a study should be recorded on Form SW-6623 and forwarded to the Engineering Department as covered in the previous paragraph.

1 The drain data developed in this section is only partially used to engineer emergency engines. Section 8.0 covers the drain requirements used to size emergency engines.

The furnished discharge drain readings reflect only that equipment being used to process calls at the particular time the drain study is taken. If the drain readings are taken for a 24-hour period during the busy season, it can usually be assumed that the drain for a maximum amount of equipment required to serve the number of working customers is being measured. There is in most offices an amount of installed equipment that is spare and consequently will not be reflected in a particular drain study. This generally includes lines and terminals, carrier channels, switchboard positions, trunks, common control equipment, etc., that can be assigned when the demand warrants. Also it can include equipment that has been removed from service for repair, routine maintenance, or reassignment. It is important to know the types and quantity of equipment that fall into this category at the time the drain readings were made. In other words the potential drain represented by this idle equipment must be added to the recorded drain readings to get a true picture of the total drain that this office can be expceted to require without any additional equipment being added. The Plant Department is responsible for listing the idle equipment on form SW6623 (see figure 4.1).

The drain readings provided on form SW6623 for a particular load (-48V, +130V, -130V, etc.) should cover a 24-hour period. For some plants this load is constant over the 24 hours and for others it fluctuates. The maximum reading is known as the busy hour (BH) peak drain and the lowest reading as the constant drain. The difference between the BH peak and the constant drain is called the BH variable drain. For plants having only a constant drain, the BH peak and constant drain are the same and there is no BH variable drain.

4.3 End of Power Engineering Period Drain

Generally, sufficient power equipment is added to handle all requirements (both circuit and switching) in an office through the engineering period (or earliest exhaust date) of the equipment being added. This two- or three-year period is known as the power engineering period and the exhaust date of the power equipment is called the end of the power engineering period.

There are basically two ways of determining the drain associated with equipment being added or spare equipment already installed in an office. The first of these methods uses broad gauge calculations; the second requires detailed calculations. The best method to use depends upon the type of equipment, availability of data and the period under study.

The broad guage method is rather straight forward and has proven quite accurate if properly applied. Its best application is usually for variable load drains. In simple terms it means finding the average drain per major entity of equipment being added (lines, terminals, frames, carrier systems, etc.) and multiplying this average times the total number of entities being added. If an addition is being made to an existing office, the average drain per entity could be obtained by dividing the existing peak drain by the total number of existing entities. For a new office it might be obtained by comparing an existing installation of similar equipment, size and calling characteristics to the proposed one.

157-801-902SW

FORM SW6623
JULY 1972

ANNUAL D.C POWER DRAIN STUDY

DIVISION ______ DISTRICT ______

CITY/TOWN ______ OFFICE ______

PLANT CODE ______ VOLTAGE ______

BATTERY PLANT ______ STRINGS ______ KS ______ LIST ______

CHARGE CAPACITY (INCL. RESERVE) ______ AMPERES ______

DATE: FROM ______ TO ______

	D.C DISCHARGE CURRENT IN AMPERES					D.C DISCHARGE CURRENT IN AMPERES			
TIME	LOAD A	LOAD B	LOAD C	TOTAL	TIME	LOAD A	LOAD B	LOAD C	TOTAL
8:00 AM					8:00 PM				
9:00 AM					9:00 PM				
10:00 AM					10:00 PM				
11:00 AM					11:00 PM				
12:00					12:00				
1:00 PM					1:00 AM				
2:00 PM					2:00 AM				
3:00 PM					3:00 AM				
4:00 PM					4:00 AM				
5:00 PM					5:00 AM				
6:00 PM					6:00 AM				
7:00 PM					7:00 AM				

SPARE EQUIPMENT:

______
______
______
______
______

This information should be added by local Plant representative.

NOTE: RETAIN 1 COPY FOR DISTRICT FILE
1 COPY TO DIVISION PLANT
1 COPY TO AREA PLANT
AREA PLANT FURNISH CHIEF ENGINEER 1 COPY

Figure 4.1 - Form SW 6623, Annual D.C. Power Drain Study

For example, assume a new 50-frame #5 crossbar office is being engineered to serve as a first tier office and it is necessary to determine the drain associated with the additional equipment. By locating another first tier #5 office of similar size, the average BH drain per frame could be determined by dividing the BH peak drain by the number of working frames. Multiplying this average drain per frame times the 50 frames would result in the estimated drain for the new crossbar office. The two main dangers associated with broad gauging are: (1) not using the proper entity and (2) not comparing offices with similar calling characteristics. In our example, had a #5 office located in a remote rural community been used in determining the average drain per frame, the different calling characteristics of the two offices might result in more or less power being actually furnished than required.

Choosing the wrong entity as the basis for establishing the average drain can also result in erroneous drain projections. For example, an addition of 70 intermediate selectors is planned in a step-by step office equipped with 400 existing intermediate selectors and having a present total office drain of 40 amperes. This would indicate 0.10 amperes of additional drain would be required for each new selector (40 ÷ 400) which is not true. The actual drain for each additional selector would be approximately 0.02 amperes (from List 1 Current Drain book).

As an example of the proper use of the averaging method, assume 600 lines are being added to a step-by-step office equipped with 2000 lines and having a BH peak drain of 80 amperes. The average drain per line of 0.04 amperes (80 ÷ 2000) is realistic and indicates that the 600 lines will require an additional 24 amperes (0.04 X 600). In using the averaging method, care must be taken to consider any changes in the characteristics of the office resulting from the addition under consideration. For instance, if in addition to 600 lines, initial ANI or "T" carrier equipment were being added, the 24 amperes would be inadequate and might result in a delay in the service date for the ANI or "T" carrier equipment. The increased use of "T" carrier is resulting in substantial constant loads in local switching offices; in many offices, it now comprises the major portion of the BH peak drain. Before the averaging method can be used in an office having substantial amounts of carrier equipment, the constant load for the carrier must be subtracted from the BH peak drain and the two drains (variable and constant) projected separately.

Averaging is not the best method for projecting constant drain loads. Most constant loads result from the steady drain requirements of carrier equipment and can easily be projected using the detailed calculation method.

Estimating drain by detailed calculations can be more involved and time consuming than averaging, but, at times, may be the only method for accurately projecting requirements. As the name implies, the drain for each individual item of equipment being added must be determined.

Drain values furnished by the Bell Telephone Laboratories are classified as List 1 or List 2 drains. List 1 drains, in general, are used in sizing the major components of the power plant. List 2 drains are normally used in sizing discharge conductors and fuses (see part B, section 6.12, for a complete discussion of List 2 drains and their uses).

Two methods may be used by the Bell Laboratories in determining the List 1 drain for a given circuit: analytical or measured.

A typical application of the analytical method involves trunks. The action of the circuit may be divided into three parts:

a) Apparatus involved in building up call.

b) Apparatus held throughout conversation.

c) Apparatus involved in restoring to normal.

For all practical purposes (a) and (c) are short compared to (b). Therefore, the current drain is figured mainly on the basis of (b) with a small percentage (5-8%) added to round out the figures represented by (a) and (c). This procedure then results in a figure representative of the average current used by the circuit during the period of the call. The amount of current multiplied by the percentage of time the circuits are occupied in the average busy hour represents the average amount of current that must be supplied in that hour by the power plant:

Average Ampere BH drain = Avg. Amperes X % of time circuit is used in the BH.

On complex circuits such as markers and senders it is virtually impossible or at least very impractical to analyze the circuit on a time sequence basis to record every bit of circuit activity and arrive at an average, usable figure. The measured method is used to record on film or paper a continuous curve representing current required throughout the progress of the call. The area under the curve is then integrated by means of a planimeter and averaged over the length of the call to arrive at an average figure.

The current drain figures obtained by either analysis or measurement are presented in the List 1 drain tables by one of two methods: equipment or traffic.

In the equipment method, the drain figures are tabulated for each circuit and the engineer must simply multiply the List 1 drain by the installed quantity of circuits to determine the total busy-hour load on the plant. This method incorporates an estimated traffic activity factor which must cover all office applications and, therefore, is usually liberal.

In the traffic method, the List 1 drain figures for each circuit are expressed in amperes per ccs. This figure is obtained by multiplying the average drain a circuit requires while in use by a factor of 100/3600. To obtain power plant loads, the engineer must multiply this figure by the total traffic (in ccs) that all circuits of this kind in the office will experience.

There are several source documents that provide List 1 circuit drain information:

1. List 1 Current Drain Book

2. Circuit Schematics (SD's) and Descriptions (CD's)

3. BSP's

4. Key Sheets

5. Application Schematics

6. Power Data Book

The List 1 Drain Book lists the drains for most circuits and KS specifications and should be used if possible. The other sources listed above can be consulted if the equipment is not listed in the List 1 Current Drain Book. The reference information in front of the Drain Book should be reviewed before attempting to apply the information it contains.

For those circuits having drain expressed as a function of ccs, the Traffic Order adding the equipment will have to be consulted in order to determine the projected usage.

To illustrate use of the List 1 Drain Book, assume 30 first selector switches per SD-30200-01 are being added in a 350A SXS office. The List 1 book indicates the drain is 0.02 amperes per switch. The calculated additional drain would be 0.6 amperes (30 X 0.02).

In more complex situations (as when projecting power requirements for a new office), a form similar to the "DC Calculation Guide" shown in Section 1 of the AT&T Power Engineering Manual may be used to facilitate the recording and calculation of List 1 drain requirements. Each circuit presenting a load on the appropriate power plant must be identified and the List 1 current drain determination made. If the List 1 drain information is expressed in terms of ccs, Traffic Order data will be required.

4.4 Selecting the Power Engineering Period

There are times when the end of power engineering period date for the power plant equipment may be different (either earlier or later) than the exhaust date of the equipment it is designed to serve. When investigating the power requirements for an office, the engineer should look beyond the current job under consideration. This insures that provision of the power equipment is consistent with future requirements of the office and that the most economical method is being used to provide for the needed power. A chart similar to the one shown in figure 4.2 will facilitate not only selection of the power engineering period but also aid in long-range power planning (see section 4.5).

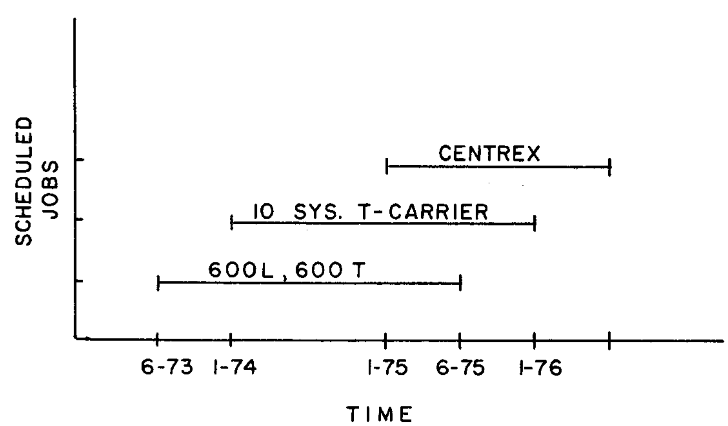


Figure 4.2 - Scheduling of Jobs to Determine End of Power Engineering Period Date

Selection of the power engineering period depends primarily on the ability of the power plant to handle the job currently being engineered. For example, assume the power investigation reveals there is adequate existing power to care for the 600L, 600T growth job. In this case, the engineer would not provide for any of the other planned jobs and the exhaust date of the power equipment would then be 1-74, the service date for the T-carrier job. If, however, it is assumed there is insufficient existing power reserve to care for the 600L and 600T growth job, the engineer should provide power for the T-carrier job as well, because of the close proximity of their service dates. The end of power engineering period date of the plant would then become 1-75, the service date of the centrex job. The power for the centrex job may or may not be provided with the switching job (due to the long delay between service dates). However, the effect the centrex job has on the ultimate power requirements for the office should be considered. To spend a great deal of money revamping the power plant and still not have it capable of handling the requirements of the centrex job would be a short-sighted approach to power planning.

4.5 Estimating Drain for Long Range Planning

Another phase of current drain calculations is that of long range forecasting. The techniques outlined in 4.3 can be used in projecting requirements for a two- to three-year period. While this is sufficient to engineer adequate power for that period, it does not insure that plans for that period are consistent with long-range requirements. Therefore, a power study should include the forecasted drain data for some future period after the end of the power engineering period. An eight-year period is usually considered to be of sufficient length to use as a long-range forecast period. The total power study views the present demand, the end of the power engineering period demand and the demand at some future date, usually eight years after the end of power engineering period date.

The end of power engineering period drains are easier to forecast than those for the future (eight-year) period because available traffic orders, specifications, MOP's etc., provide a fairly accurate count of the types and quantities of equipment which will be installed. However, the estimates of the future (eight-year) drains must be made from less concrete data. In some cases, the only data available might be past history. In others, new wire center area forecasts, toll fundamental plans, Plant Extension studies (actual and proposed), etc., may be used in making this projection. The future drain projection must incorporate both power drain trends based on past requirements and additional drain associated with new equipment vehicles.

4.6 Power Failure Drain

During a commercial AC power failure in an office, there is certain critical equipment that is normally AC operated that reverts to DC battery operation until either an emergency engine-alternator is started or the commercial AC power is restored. Ringing machines (only if normally AC operated), inverters, and emergency lights are examples of this type of equipment. These additional DC drain requirements are referred to as the "power failure drain". The power failure drain is used only in sizing batteries and DC distribution systems (but not in sizing the charging equipment). The application of power failure drain in sizing batteries is covered in more detail in part B, section 7.4.

4.7 Drain Data Entries - SWX-XXXX-550-G Drawing

Drain data entries for the SWX-XXXX-550-G drawing are shown in figure 4.3.

Part IIA - Shows the current status of the power plant drain. This is derived directly from the latest form SW6623 furnished by the Plant Department. In those cases where the power plant has more than one discharge load, the drain per load must be recorded. This can be done by showing the load designation next to the drain - 120A, 120B, 200C and recorded in IIA as follows:

1.	BH Peak Drain	120A, 120B, 200C	Amps
2.	Constant Drain	20A, 30B, 30C	Amps
3.	BH Variable Drain	100A, 90B, 170C	Amps

Part IIB - The projected additional power plant drain is recorded in Part IIB and is calculated as shown in section 4.3. This drain includes both spare or idle equipment in the office and that equipment engineered, but not yet installed. Once the actual service date for a job has passed, the job can be removed from IIB provided the date of the latest drain readings shown in IIA is later than the service date. The actual service date for a job may be different than that recorded in IIB as the forecasted date. Before removing a job from IIB, the engineer should verify the actual service date.

In some cases an engineer may be providing a power plant to care for more than the job currently being engineered, especially when a plant is shared by more than one type of equipment or the equipment is engineered by different persons or groups. The engineer providing the power should record in part IIB all jobs that were included in the drain calculations, and show the estimated drain attributable to each job. For example, in figure 4.3 the 9311.72 specification is also providing enough power to care for the job shown on JRS 3130. When job 3130 is engineered, the engineer responsible for the job should replace the job number with the specification number and show his initials below those of the other engineer. At this time he should also verify that the estimated drain data used by the first engineer is correct. If it is found to have changed, the 550 drawing should be updated to determine if the power plant is adequate.

Part IIC - The information in Part IIA of the 550 drawing is repeated on line 1 of Part IIC. Line 2 is the total of all drains listed in IIB. Before obtaining this total, make sure all jobs have been removed from Part IIB that are also reflected in Part IIA. Line 3 is the total projected drain that is used to verify the adequacy of the existing plant and to engineer power equipment.

Part IID - This section is used to record the DC drain of equipment that is normally AC powered but reverts to DC operation during a power failure.

II LOAD DATA

A. LATEST DC DRAIN READING INFORMATION, FROM SW 6623,(DATE: 9-10-72)

1. B.H. PEAK DRAIN 160 AMPS 70A,90B
2. CONSTANT DRAIN 52 AMPS 30A,22B
3. B.H. VARIABLE DRAIN 108 AMPS 40A,68B

B. PROJECTED ADDITIONAL B.H. DRAIN FOR EQUIPMENT INSTALLED OR PLACED INTO SERVICE AFTER DATE OF LATEST DRAIN READING AND INCLUDED IN POWER ENGINEERING PERIOD.

SPEC OR JOB #	SERVICE DATE	DRAIN ADDED			ENGR	NOTE
		B.H. PK	CONST	VAR		
SPARE	X	15	10	5	ABC	1
4431.102	6-75	20	20	—	RDC	
4431.104	9-75	25	5	20	RDC	

SPEC OR JOB #	SERVICE DATE	DRAIN ADDED			ENGR	NOTE
		B.H. PK	CONST	VAR		
TOTAL		60	35	25	X	

NOTES:

1. DRAIN ATTRIBUTABLE TO SPARE EQUIPMENT IN OFFICE AT DATE OF LATEST DRAIN READING.
2. NEW POWER PLANT PROVIDED ON THIS SPEC.

C. PROJECTED B.H. DRAIN, END OF POWER ENGINEERING PERIOD

	B.H. PEAK	CONST	VAR
1. PRESENT B.H. DRAIN (FROM IIA)	160	52	108
2. PROJECTED ADDITIONAL DRAIN (FROM IIB)	60	35	25
3. TOTAL PROJECTED B.H. DRAIN (LINES 1 + 2), PWR. ENGR PER	220	87	133

D. POWER FAILURE D.C. DRAIN

	PRESENT	PWR. ENGR. PER	
1. EMERGENCY LIGHTING	10	10	
2. RINGING MACHINE	—	—	(IF NORMALLY AC OPERATED)
3. AC POWER PLANTS	66	66	(ONLY INCLUDE IF TRANSF TO DC IF AC FAILS)
4. OTHER	—	—	(INCLUDES ________)
5. TOTAL	76	76	

Figure 4.3 - Drain Data Entries, SWX-XXXX-550-G Drawing

PART B - SECTION 5.0
AC EQUIPMENT

5.1 Typical AC Layout

Commercial AC power is used in a telephone central office building for two functions: (1) to operate the various building equipments and (2) to power the telephone equipment. The power company supplies the necessary meters and protective equipment to terminate the commercial AC leads in a main building AC power panel or distribution point (usually called a house service cabinet). From this central power panel, the AC power is distributed to the various building equipments and the telephone power plants.

Figure 5.1 shows a typical method used to derive 208 and 120 volts using a 3-phase, four-wire output from a step-down line transformer. Most offices are supplied with 120/208, 3-phase, 4-wire AC power. Those smaller offices working on 110/220 volt, single-phase AC should be converted to 120/208, 3-phase, 4-wire service (normally in conjunction with a building addition) if 3-phase service is available from the power company (this conversion is desirable for two reasons: (1) in those locations requiring access to portable standby emergency engines, the necessity of having both single and three-phase sets readily available is eliminated as all or most offices are converted to three-phase service, and (2) the economies of three-phase operation and limited availability of single-phase AC equipment, as air conditioners, required for larger buildings dictate use of three-phase service as buildings are expanded). In many of our larger central offices, AC power is supplied at a higher voltage than 208 volts (as 440 volts). In that case, the Telephone Company may have to supply its own step-down transformers if lower AC voltages are required.

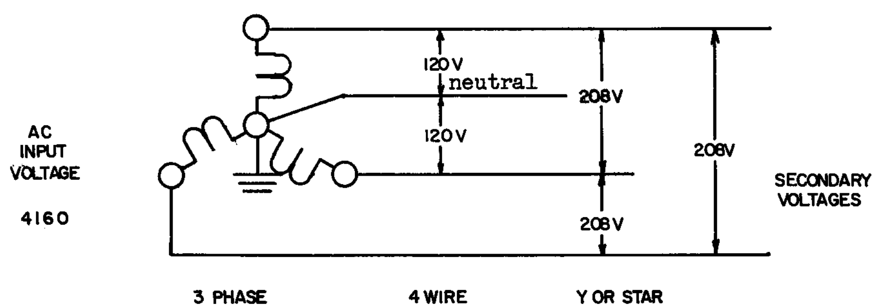


Figure 5.1 - Method for Deriving 120/208-Volt, 3-Phase, 4-Wire AC Power

Power factor is a term used to describe the relationship between an AC current wave and a voltage wave. If these waves are in phase with each other, the power factor is 1.0. A "lagging" power factor exists when the current wave lags behind the voltage wave. A "leading" power factor results when the current wave leads the voltage wave. The technical explanation of power factors is quite complicated. However, it should be pointed out that a low power factor results in current which does no useful work, but is merely dissipated as heat. This condition can be measured using a power factor meter. Although commercial AC having a power factor of 0.8 to 0.9 is generally available, in some cases, steps must be taken by either the power company or the Telephone Company to correct a low power factor.

Various methods are used to distribute power service to power equipment located on various floors of a telephone building. The arrangement shown in figure 5.2 is typical of a medium-size central office.

The functions of the primary AC distribution equipment elements are as follows:

- House service cabinet (may also be referred to as the main power service panel, main AC switchboard or the house service board) - includes the necessary switches, meters and protective equipment for terminating the commercial AC power source in a central office building. The house service cabinet may also contain an alarm panel and a set of status indicating lamps. If an emergency AC source is installed in the office, its output is terminated in the house service cabinet for emergency AC power distribution to telephone and building equipment, see part B, section 8.3 for a list of those items served from the emergency bus. The house service cabinet distributes, through circuit breakers, AC power to building power panels and, in many

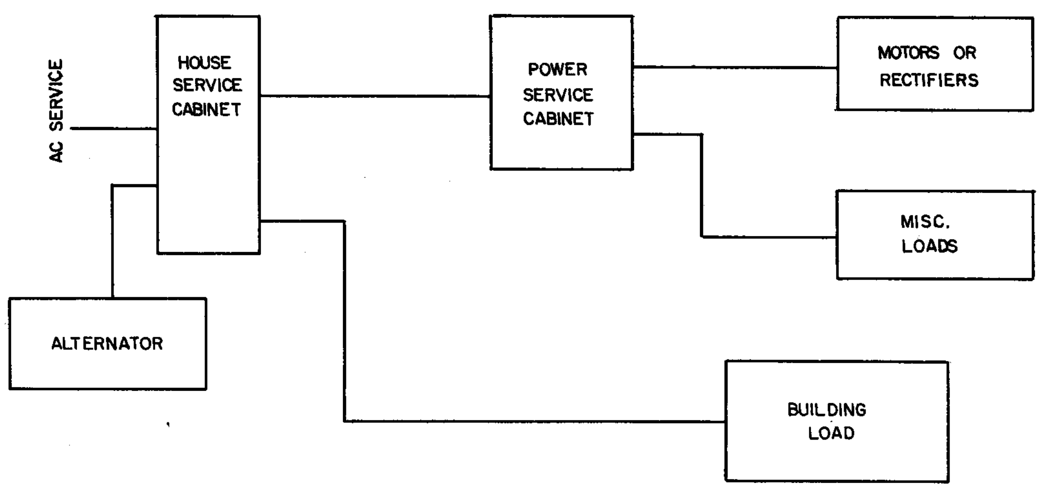


Figure 5.2 - AC Distribution, Medium-Sized Central Office

offices, to telephone equipment via a power service cabinet (see BSP's in 770-280-XXX series).

- Power service cabinet - AC leads from the house service cabinet may be terminated in a power service cabinet for further distribution to telephone equipment. Some offices have only one power service cabinet, usually located on the same floor as the charging equipment. The power service cabinet may be either bay or wall mounted. In larger offices, although one power service cabinet may be located on each of the equipment floors, power plant charging equipment will be fed directly from an AC bus distribution system rather than through a power service cabinet. This arrangement is shown in Figure 5.3. The power service cabinet may be fed either from the bus system or directly from the house service cabinet.

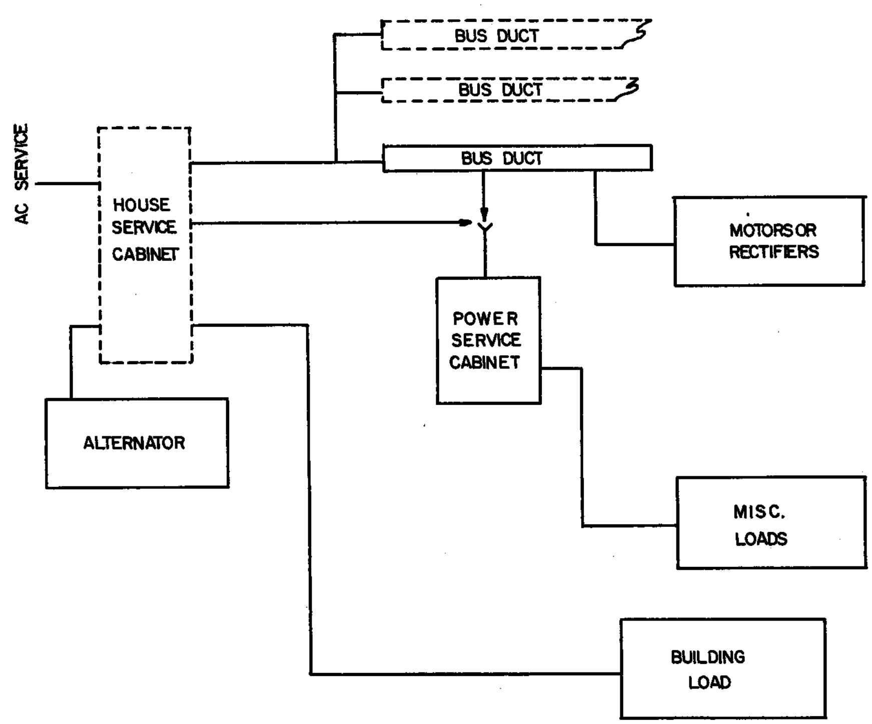


Figure 5.3 - AC Distribution System, Large Central Office

General requirements for AC bus systems are included in BSP 802-004-151. If there are three or fewer floor-mounted charging units in an ultimate plant, leads from the house service cabinet will usually terminate in a power service cabinet which will then feed the charging equipment. If there are four or more ultimate floor-mounted charging units, the leads from the house service cabinet will usually terminate in bus ducts located over the charging units. A separate duct is usually porvided for each row of charging units. Leads between the switch and fuse units on the bus duct or power service cabinet and the charging units or miscellaneous loads shall be sized to meet the requirements of the appropriate circuits.

In smaller offices, the commercial AC leads will be terminated in a wall mounted AC terminal box as shown in figure 5.4. In this case, both the telephone and equipment loads are supplied directly from the AC terminal box.

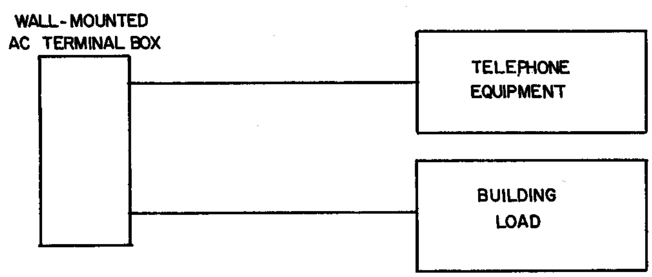


Figure 5.4 - AC Distribution System, Small Office

5.2 House Service Cabinet

As covered in section 5.1, the house service cabinet (also referred to as the house service board, AC switchboard or main power service panel) provides the necessary switches, meters and protective equipment for terminating the commercial AC power source in a central office building. A typical house service cabinet arrangement is shown in the single-line diagram of figure 5.5 (each line represents 3 phases).

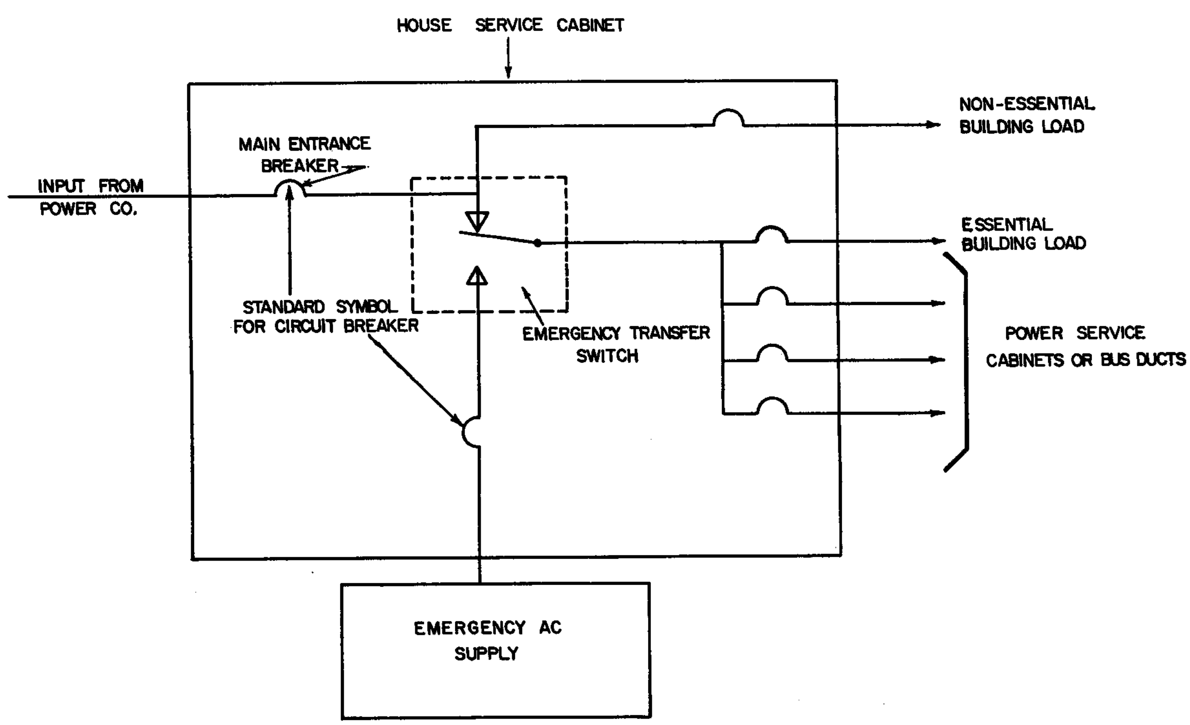


Figure 5.5 - Typical House Service Cabinet

Under normal operation, the commercial AC supplies power for all building and telephone equipment. Upon failure of the commercial AC, the emergency transfer switch is operated and the telephone equipment and essential building load is transferred to the emergency AC supply (usually an emergency diesel engine or turbine-driven alternator). Included in the essential building load are those items which must remain operable to insure the safety of either the building or its occupants: ventilating fans, sump pumps, portions of building lighting, an elevator (in multi-story buildings), etc. Some house service cabinets are equipped with two transfer switches. One switch is used to transfer regular telephone equipment during both emergency and load test conditions. The second switch transfers those items which should not be transferred during regular engine test because of the potential for service interruption. The primary responsibility for design of the house service cabinet lies with an electrical engineering consulting firm. The Telephone Company Architectural group provides the consulting firm with the telephone equipment requirements for either a new building or building addition. The consulting firm is also advised of those items which must be transferred to the emergency AC source upon commercial power failure. The consulting firm then designs the house service cabinet, incorporating both the telephone equipment requirements supplied by the Architectural group and the building requirements which are determined by the consulting firm. Detailed information about a house service cabinet may be obtained from the Architectural group's electrical details drawing for a specific central office building.

Western Electric has no engineering responsibilities as far as the house service cabinet is concerned. All electrical work (including terminations) in the house service cabinet is handled by an electrical contractor who is directly responsible to the Telephone Company's Architectural engineering group. The Architectural group is responsible for all additions and rearrangements in the house service cabinet. In many cases, tap boxes will be provided for terminating Western Electric run power cable. Western Electric Engineering is responsible for designing the remaining portions of the AC distribution system. Decisions to employ power service cabinets, bus ducts, etc., are dependent upon the size of the office and its present and ultimate AC requirements.

5.3 Power Service Cabinet and Distribution System

As covered in section 5.1, AC leads from the house service cabinet may be terminated in a power service cabinet for further distribution to telephone equipment. Western Electric has complete engineering responsibility for design of the AC distribution system, including any power service cabinets in the central office. Engineering details for power service cabinets are included on Western Electric T drawings for the office. A separate AC distribution drawing may be initiated for larger offices. For smaller offices, the AC distribution information may be included on the wiring list and block schematic for the largest plant in the office.

A typical T drawing layout for a power service cabinet is shown in figure 5.6. The physical layout of the fuses in the cabinet is included in sketch A. Sketch B reflects the capacity and assignment

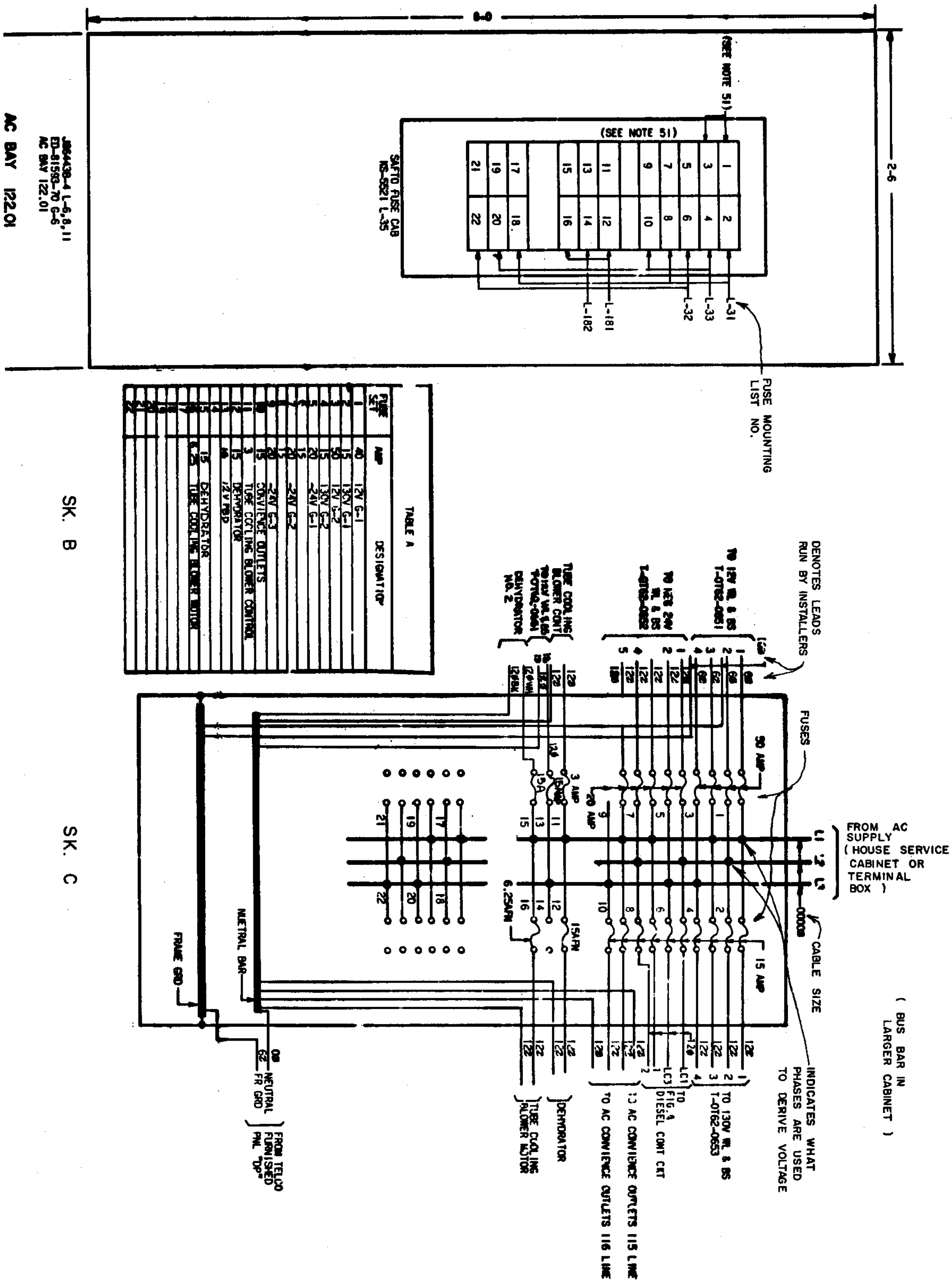


Figure 5.6 - Typical Western Electric T-Drawing Detailing Power Service Cabinet Assignments

for each of the fuses in the cabinet. Detailed cabling and circuit layout information is provided in sketch C. In some cases, these three related sketches may not be shown on the same drawing.

The method employed in distributing AC power to telephone equipment will depend upon the size of the office. All AC cabling is run in conduit for protective reasons. Where bus bar or duct is utilized in distribuitng AC power to charging equipment (see section 5.1 and BSP 802-004-151), cable is used to connect the bus with the appropriate breaker on the house service cabinet. A typical AC distribution system employing the bus arrangement is shown in figure 5.7. The capacity of AC bus is specified assuming adequate ventialtion. Although bus manufacturers have not been able to define "adequate" ventilation, care should be taken to insure that reasonable clearance is maintained between the bus and air ducts, piping, stored items, etc.

5.4 Engineering Responsibilities

As covered earlier, the Telephone Company architectural engineer is responsible for providing the electrical consulting engineering firm with the necessary information for provision of house service cabinet equipment and for specifying the method of connection on both the primary and secondary side of the line transformer. Responsibility for providing the necessary AC distribution equipment to handle the additional equipment requested by the Telephone Company equipment engineer lies with Western Electric engineering. If, at any time during engineering of a job, Western Electric engineering determines that additional house service cabinet equipment is required to serve AC distribution equipment being added or rearranged, the Telephone Company equipment engineer is notified. The Telephone Company equipment engineer is responsible for advising the Architectural group of the additional requirements and insuring that installation of the house service cabinet equipment is completed by the time the telephone equipment job is installed.

After initial installation of AC equipment, the Telephone Company equipment engineer is responsible for notifying the Architectural Engineer of any changes in AC requirements resulting from a change in the telephone equipment load (as the addition of a rectifier). Each time a change is made in the total installed charge capacity, a copy of the "Power Plant Data Sheet," form SW-5073, for the job affecting the change should be forwarded to the Architectural group (see part C, section 1.2). The Architectural group will review the new requirements to insure that the AC entrance and power company transformer equipment is properly sized to meet the needs of that job.

The Telephone Company equipment engineer is also responsible for completing the AC data section of the SWX-XXXX-550-G drawing as outlined in section 5.5.

5.5 AC Data Entries, SWX-XXXX-550-G Drawing

The only AC data which will be recorded on the SWX-XXXX-550-G drawing is shown in figure 5.8. This section will only be completed for offices having a stationary emergency AC supply (diesel or turbine

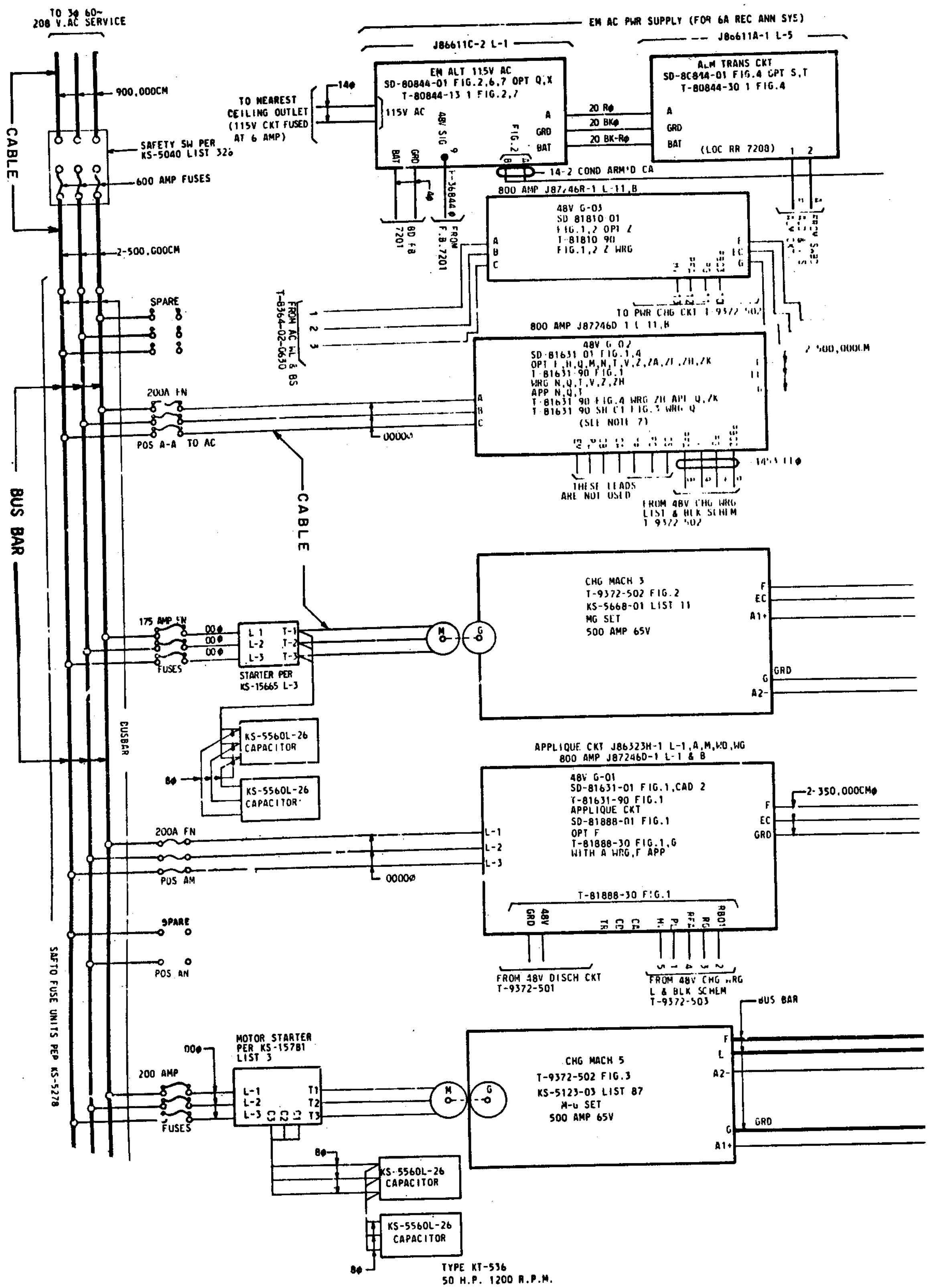


Figure 5.7 - AC Distribution System Employing Bus Duct

driven). This information will be used in analyzing emergency engine run data as covered in section 8.0. The standard format shown in figure 5.8 can probably be used for most offices. However, more complicated house service cabinet arrangements are used in large offices and the format must be redesigned in order to reflect all house service cabinets having emergency buses supplied by emergency AC supplies.

The information required to complete this section can be obtained from the architectural electrical details drawing for the office or from a field verification made by the local plant representative.

V AC DATA — HOUSE SERVICE CABINET

SW. NO.	CAPACITY	USE	SW. NO.	CAPACITY	USE
1	100 A	TELEPHONE POWER			
2	60 A	BUILDING LIGHTS			
3	60 A	AC UNIT #1, VENT. EQ.			
4	60A	AC UNIT			
5	30A	COOLING TOWER FAN			
6	30A	SPARE			

Figure 5.8 - AC Data Entries, SWX-XXXX-550-G Drawing

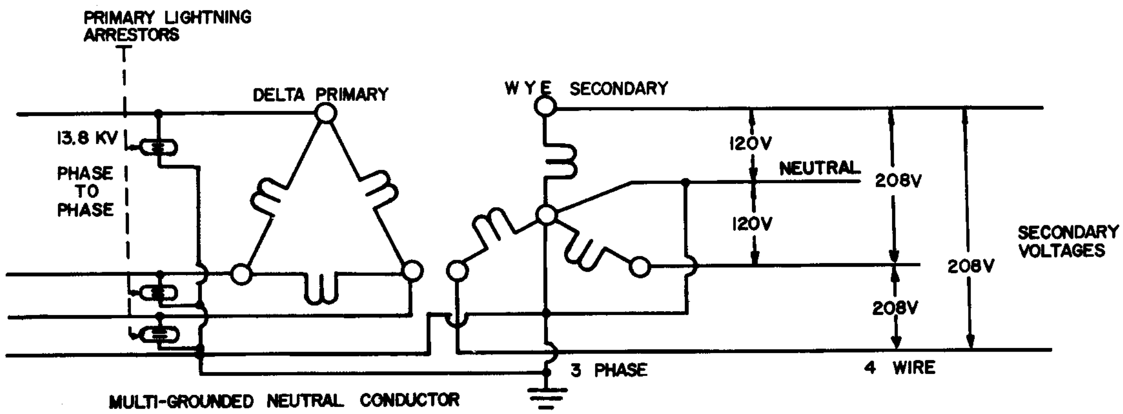
5.6 Commercial Power Considerations

There are certain important power and protection-related considerations that Telephone Company equipment engineers and architects must consider when preparing detailed plans for buildings that house telephone equipment. Power company engineers will base the design of power services entering the new or rearranged buildings on these considerations. In the past it has been customary to only furnish details for power service on secondary systems, without specifying the method of connection on the primary side of the line transformer.

Figure 5.9 details the proper method to be used to derive 120/208 volts using a three-phase, four-wire, wye-connected secondary output from a three-phase line transformer arrangement with a delta connection on the primary side. It is important that the delta-primary, wye-secondary connection be indicated in lieu of a wye-wye arrangement in order to prevent third harmonic currents from entering the equipment premises through the secondary wiring system.

Figures 5.10 and 5.11 detail the proper method to be used to derive 110/220 volts from a single-phase line transformer using a three-wire secondary system.

With the exception of certain mid-city underground power distribution areas, most power companies are using the wye-type primary system. A multi-grounded neutral conductor is generally carried along with the phase wires throughout these systems. Even though a delta connection is specified on the primary side of the transformer, the system neutral should be made available at the transformer so that a permanent and common connection can be made to the neutral conductor of the secondary system. This interconnection of neutral conductors (see figure 5.9) will afford the secondary neutral to be "effectively ground"

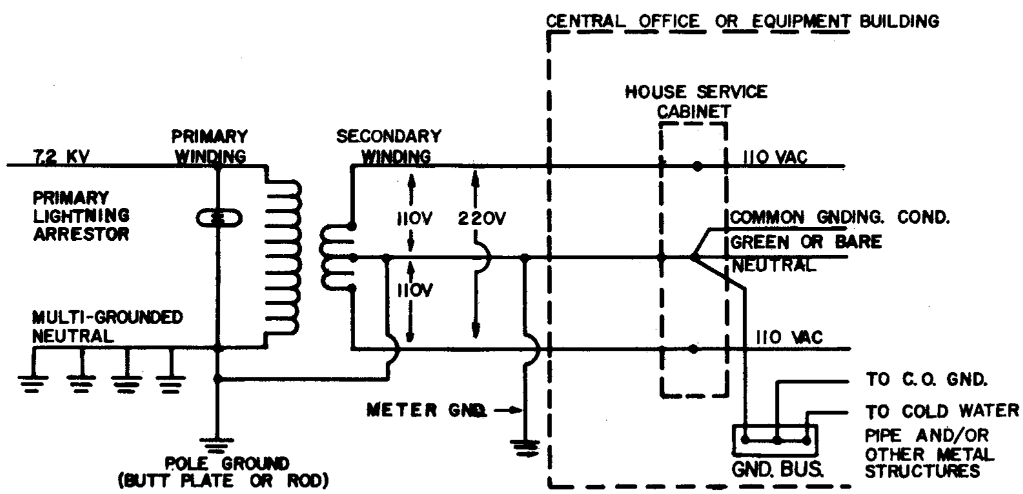


SPECIAL NOTES

1. NOTE PERMANENT INTERCONNECTION OF PRIMARY LIGHTNING ARRESTOR GROUND WITH SECONDARY NEUTRAL AND THE MULTI-GROUNDED SYSTEM NEUTRAL. THIS INTERCONNECTION BETWEEN THE LIGHTNING ARRESTOR GROUND AND THE SECONDARY NEUTRAL SHOULD NOT BE MADE UNLESS THE MULTI-GROUNDED NEUTRAL IS AVAILABLE FOR A COMMON CONNECTION. (SEE N E S C HANDBOOK NO. 81, PAGE 25, PAR. C, SEC. 97). COSTLY DAMAGE TO CENTRAL OFFICE RECTIFIER EQUIPMENT HAS OCCURRED WHEN LIGHTNING HITS ON THE PRIMARY POWER SYSTEM WERE DRAWN INTO TELEPHONE EQUIPMENT PREMISES WHERE SECONDARY NEUTRALS WERE CONNECTED COMMON WITH PRIMARY LIGHTNING ARRESTOR GROUNDS WITHOUT THE BENEFIT OF A MULTI-GROUNDED NEUTRAL CONNECTION. IN THE CASE OF MAIN REPEATER STATIONS ON TOLL CABLE ROUTES, COMPARATIVE WIRING ERRORS HAVE RESULTED IN SIMILAR LIGHTNING HITS BEING DRAWN INTO STATION PREMISES AND CAUSING EXTENSIVE SHEATH DAMAGE ON BURIED CABLE EXTENDING IN BOTH DIRECTIONS FROM THE STATION. INTERCONNECTION OF THE SECONDARY NEUTRAL WITH THE STATION GROUND AND THE IN-AND-OUT CABLE SHEATHS IS STANDARD PROCEDURE. HOWEVER, IT MUST BE CERTIFIED THAT SUCH INTERCONNECTION INVOLVES A COMMON CONNECTION TO A MULTI-GROUNDED NEUTRAL AT THE TRANSFORMER.

2. USE OF DELTA-WYE IN LIEU OF THE WYE-WYE METHOD OF CONNECTING TRANSFORMERS WILL PREVENT ENTRY OF THIRD HARMONIC CURRENT INTO THE SECONDARY SYSTEM, CAUSING VOICE FREQUENCY NOISE INTERFERENCE.

Figure 5.9 - Method for Deriving 120/208 Secondary Voltages from a Delta-Wye Transformer Connection

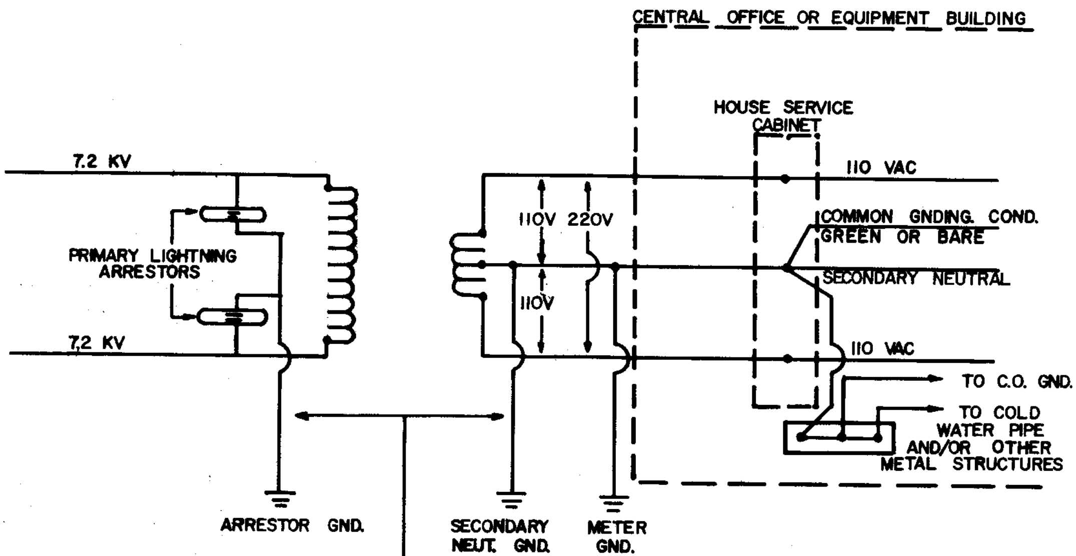


SPECIAL NOTES

1. NOTE PERMANENT INTERCONNECTION OF PRIMARY LIGHTNING ARRESTOR GROUND WITH SECONDARY NEUTRAL AND THE MULTI-GROUNDED SYSTEM NEUTRAL. THIS INTERCONNECTION BETWEEN THE ARRESTOR GROUND AND THE SECONDARY NEUTRAL SHOULD NOT BE MADE UNLESS THE MULTI-GROUNDED SYSTEM NEUTRAL IS AVAILABLE FOR A COMMON CONNECTION.

2. SINGLE PHASE PRIMARY SERVICE IS GENERALLY PROVIDED AT MAIN REPEATER STATIONS, MOBILE TOWER SITES, AND OTHER INSTALLATIONS WHERE 110-220 VOLT SERVICE IS REQUESTED.

Figure 5.10 - Method for Deriving 110/220 Secondary Voltages from a Single-Phase Line Transformer Using a Three-Wire Secondary System and Phase-To-Neutral Primary Connection



CAUTION

DO NOT ALLOW INTERCONNECTION OF THE ARRESTOR GROUND WITH THE SECONDARY NEUTRAL IN CASES WHERE THE MULTI-GROUNDED SYSTEM NEUTRAL IS NOT AVAILABLE.

SPECIAL CONSIDERATIONS FOR INTERCONNECTING PRIMARY LIGHTNING ARRESTOR GROUNDS AT TRANSFORMERS WHERE THE MULTI-GROUNDED NEUTRALS ARE NOT AVAILABLE ARE OUTLINED NESC HANDBOOK NO. 81, PAGE 25, PAR. C, SEC. 97.

Figure 5.11 - Method for Deriving 110/220 Secondary Voltages from a Single-Phase Line Transformer Using a Three-Wire Secondary System and Phase-To-Phase Primary Operation

and will allow it to be bonded common with the central office ground. There is substantial reasoning that the bond between the secondary neutral and the central office ground should not be made if it cannot be ascertained that the neutral conductor is permanently and electrically connected to a multi-grounded system neutral. A system neutral is considered multi-grounded if it affords a minimum of four pole ground wires per mile of construction. Customer-owned grounds at meter locations are not to be considered.

Connections between secondary neutrals and single ground electrodes serving primary lightning arrestors on the field side of transformers should not be tolerated unless a multi-grounded neutral is available and a common and permanent connection can be made between the three (see figure 5.9). This consideration is being violated by many major power companies in spite of clear-cut rules outlined in both the NEC and NESC.

Where effective or low impedance grounding sources are concerned, any consideration of cold water pipes as dependable grounding mediums should be de-emphasized. Due to increased use of plastic pipe and insulated joints for electrolysis control, the metallic continuity of water pipes is no longer dependable. However, it is important to continue adherence to the practice of making a common bond between the on-premise metallic water pipes and other metallic structures and ground systems in order to prevent hazardous and damaging potential differences during certain high voltage faults or lightning hits.

PART B - SECTION 6.0
CHARGE AND DISCHARGE EQUIPMENT

6.1 Typical Layout

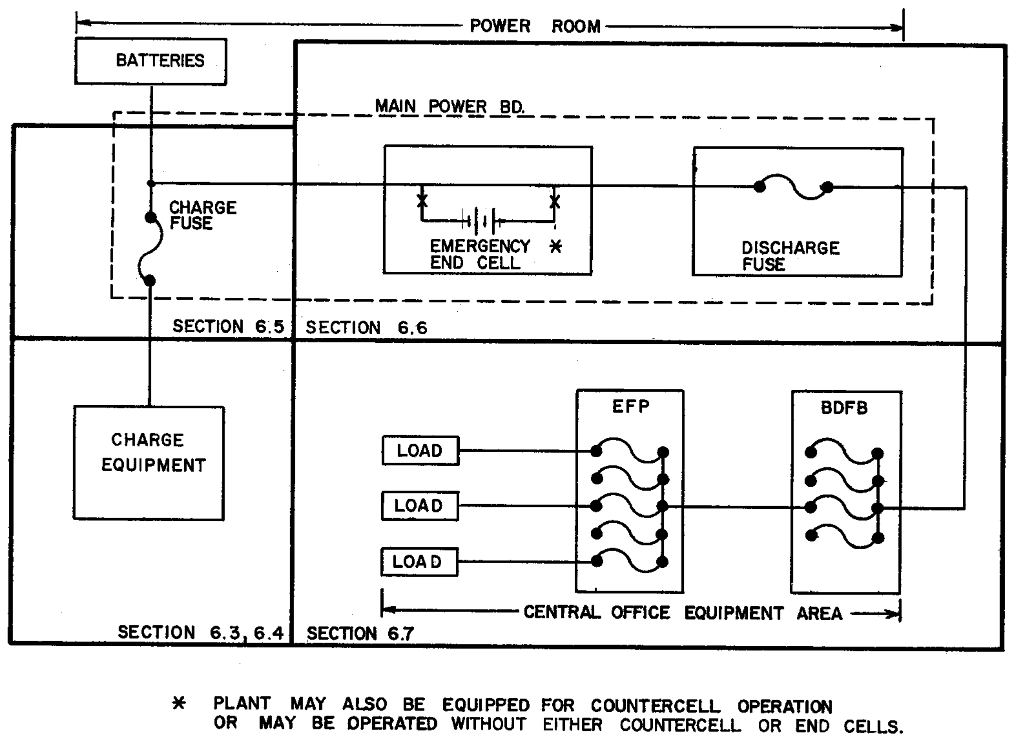


Figure 6.1 - Typical Layout of Charge and Discharge Equipment

Figure 6.1 is a typical layout of the charge and discharge equipment normally associated with a power plant. The various equipment entities are discussed in detail in the sections as indicated in figure 6.1. In addition, busbar sizing is covered in section 6.8, emergency cell switch sizing in section 6.9 and battery equipment is covered in part B, section 7.0.

6.2 Motor - Generators (M-G)

Motor - generator (M-G) sets were used in early telephone power plants to derive DC current. These sets consist of a DC generator driven by an AC motor. Rectifiers are now provided instead of M-G sets in new power plants and are also used when additional charge capacity is required in older plants. The various power plant BSP's and SD's list the associated rectifier equipment that can be used to replace or add charge units in a power plant equipped with M-G sets.

M-G sets were manufactured in various voltages and ranged in size from 100- to 1200-ampere capacity. When compared to rectifiers, M-G sets have several disadvantages: high maintenance, low efficiency, high heat dissipation, slow voltage response, noisy operation and large floor space requirements.

The very early M-G power plants were entirely manually regulated. As the load in an office fluctuated, these sets would have to be manually started and placed on the line to furnish additional current. When the load dropped they were manually stopped. Later versions of these plants provided for sequential operation: automatic starting and regulation as the load increased and automatic stopping as the load decreased. However, due to their mechanical characteristics, M-G sets are slow to respond to fast changes in load drains which at times results in voltage fluctuation problems.

There is no planned program to replace M-G sets with rectifiers in existing power plants. The replacement will usually be dictated by either high maintenance cost and/or need for the floor space occupied by the M-G sets. Replacement parts for some of the older vintage sets are not available except from other sets that have been removed and are dismantled for parts. Since the floor space required for a rectifier is considerably less than that required for a M-G set, in certain cases the only way to gain the floor space necessary to increase the charging capacity of a plant is by replacing a M-G set with rectifier(s). Most power plants are limited in the number of charging units which can be controlled; in some cases, it may be necessary to replace a small capacity M-G with a larger capacity rectifier in order to gain additional charging capacity.

Most power plants equipped with M-G sets have been arranged for GO operation when a M-G set has been replaced or a rectifier added to increase the charge capability. The GO feature should be used when available because the load sharing feature it provides is superior to the raise-lower operation of M-G sets. GO operation is discussed in further detail in 6.3. The power plant charge-discharge circuit and plant BSP will reveal how the GO feature is to be applied for a particular plant. The AT&T Power Engineering Manual also discusses GO operation under section 2.

6.3 Rectifiers and Trickle Chargers

Rectifiers are used in all new power plants and as replacements for M-G sets in older plants to derive the DC voltages necessary to power telephone equipment. The two basic types of rectifiers used in telephone power plants are electron tube and semiconductor. Capacities of these rectifiers range from a fraction of an ampere to 1600 amperes. Those rated at 100 amperes and below are generally bay or relay rack mounted, while those rated above 100 amperes are floor-mounted single-rectifier units. The various power plant BSP's and charge circuit SD's list the rectifiers that can be used with each power plant. BSP 802-001-152 and the AT&T Power Engineering Manual also list most available rectifiers and their characteristics. However, these references are not updated at frequent intervals and cannot be relied upon to furnish information about some of the newer types of rectifiers. BSP 802-000-000 also indexes most rectifiers that are now rated A & M or standard.

The electron tube rectifiers were the first type developed and were used in the early power plants arranged for rectifier operation. This type of rectifier has several disadvantages: low maximum capacity (around 12 amperes), high heat dissipation, requires warm-up time for the tubes and periodic replacement of electron tubes. In addition, the maximum output of some of the electron tube rectifiers could not be sustained for a continuous period and, therefore, required two capacity ratings: intermittent and continuous. The continuous value should be used in determining charge requirements for powering telephone equipment since the intermittent value can only be maintained for short periods. Some of the older plants that used electron tube rectifiers have been modified to provide for the addition of semiconductor-type rectifiers if the first rectifier is an electron tube type. The plant BSP's and charge circuits cover the availability and procedures for modifying a plant for semiconductor-type rectifiers.

Another improvement available in some power plants is the replacement of electron tubes in an electron tube type rectifier with semiconductor devices (rather than completely replacing the rectifier). This has two advantages: it eliminates the need for periodic replacement of the tubes, and it usually increases the output capacity of the rectifier. The appropriate rectifier BSP indicates if the conversion can be made and lists the equipment required to make the conversion. This modification, if available, should be made on a next-job basis.

In addition to being classified as electron tube or semiconductor, rectifiers are also categorized as unregulated, manually regulated or automatically regulated. Unregulated charging units are either on or off with no regulation adjustments available. This type of charging unit has limited application and, except for portable battery cell chargers, is usually rated at no more than one ampere of charge capacity.

The automatic and manually regulated charging units both have means for increasing or decreasing their output depending upon the requirements of the load. The manually regulated rectifier, as the name implies, must be adjusted manually by Plant personnel and must be monitored to determine when the adjustments are necessary. The automatically regulated plants utilize electronic regulation and control circuitry in performing these two functions and, therefore, lend themselves to unattended operation (unless trouble develops). This automatic regulation is usually accomplished using a voltage relay bridged across the main battery. As long as the battery voltage remains at its proper value, this relay remains unoperated. If the battery voltage becomes too high or too low (based on changes in the load), one of two relay contacts is closed, causing operation of either the L (lower) or R (raise) relay. Operation of either of these relays causes a motor driven field rheostat to move in the proper direction and restore the generator voltage to the required output or, in the case of a rectifier, cause the electronic control circuit to raise or lower the rectifier output as required.

To avoid overloading the charging unit, an ammeter relay is inserted in series with the output leads. When the unit is fully loaded, a contact on this relay closes causing a relay to operate and open the regulating voltage relay circuit. This prevents any further attempt by the relay to increase the charging unit output.

Many automatically regulated power plants will require more than one rectifier or M-G set to carry the maximum load. These charging units can either be arranged to operate in parallel operation (using voltage regulation) or sequence operation (using both voltage and current regulation). In parallel operation all charging units are on at all times and share the load. As the load increases or decreases, their outputs are all increased or decreased equally. Figure 6.2 shows how the output ammeters for three rectifiers operating in parallel might look.

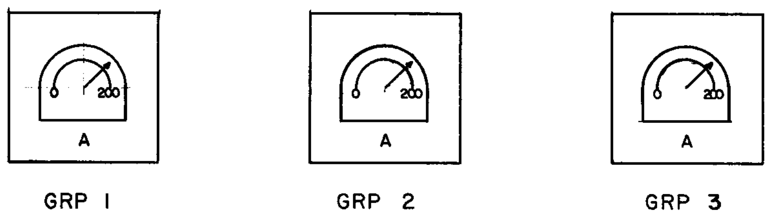


Figure 6.2 - Output Meters for Parallel Rectifier Operation

These ammeters indicate that all units are operating and sharing the load in a manner known as GO operation. Different arrangements of GO operation are available:

- Most new, standard plants are equipped for GO operation.
- Some older plants, as the 110A, may be modified for GO operation but actually use a combination of parallel (GO) and sequential operation. In the 110A, the load C (or B rectifiers in a 520-amp plant) are designated as GO rectifiers and, electrically, are the first to operate. As they reach maximum output, rectifiers in the other load(s) are turned on sequentially at maximum output and the GO rectifiers are regulated back to handle load fluctuations.
- In older plants having M-G sets or non-GO rectifiers and M-G sets, GO rectifiers must be added and arranged electrically as the first charge units. The GO rectifiers will share the load equally until they reach maximum output. At that time, the M-G sets or non-GO rectifiers will be turned on sequentially at maximum output and the GO rectifiers regulated back to handle load fluctuations. In older plants, substantial modification of the control circuitry may be required to permit GO operation, especially in 301C plants.

In the sequential arrangement, only the unit or units needed to carry the load at a particular time are operating. In sequential operation, the first charging unit is operating under voltage regulation until it reaches its maximum output. At that time it becomes current regulated and calls in the next charging unit. This same sequence continues as long as the load increases or the last unit has been turned on. Figure 6.3 shows how the output ammeters might look for four charging units arranged for sequential operation. The output ammeters shown in figure 6.3 indicate that only the units needed to supply the load are in operation. The last unit (#3) will be voltage regulated and all other operating units will be current regulated (at a fixed current output referred to as constant current).

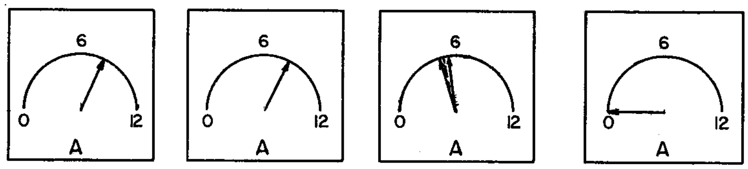


Figure 6.3 - Output Meters for Sequential Rectifier Operation

In many older plants employing a mixture of M-G sets and rectifiers, the control circuitry must be job-engineered (per Bell Labs recommendations) each time a rectifier is added to increase the charge capacity. Although the Western Electric Company engineer is responsible for detailing the changes in the control circuitry, the Telephone Company engineer should review the operating features of the control circuitry after engineering is completed to insure that the various charging units are brought on-line in the proper manner. (A note may be included in the power section of the Telephone Company specification asking the Western Electric engineer to review the operating features of the control circuitry with the Telephone Company engineer after detailed engineering is completed).

All but the smallest capacity power plants usually provide a choice in the size of rectifiers available for use in the plant. Each of the power plant BSP's and SD's list the associated rectifiers. The choice of the size rectifier to use depends upon the load to be powered, economics, and the proper limiting factors.

As an example, the 303A power plant offers the choice among the 4 pack bay (1 to 4 100-amp rectifiers), a 400-amp floor-mounted rectifier, and an 800-amp floor-mounted rectifier. The number of charge bays is limited to six and the plant capacity to 2000 amps. The first factor to consider is the load. In this example assume that the 303A plant has been selected as outlined in part B, section 2 and that the initial load is 610 amps. In this case, any of the following arrangements can be used: 2 800-amp rectifiers (1 as maintenance spare), 3 400-amp rectifiers (1 as maintenance spare), or 2 400-amp rectifiers and 3 100-amp rectifiers on a 4 pack bay (1 400-amp rectifier as maintenance spare). The PWAC economic selection technique outlined in part B, section 2 should be used in selecting the optimum size rectifier to be used in a plant.

The sample study developed in part B, section 2 assumes for the sake of simplicity the use of 400-amp rectifiers. This study should be expanded to include plans in which the plant is equipped with other rectifier arrangements which meet the load requirements of the plant. In the 303A plant, the limit of six rectifier bays is not a factor in the selection of rectifiers, but in other plants it might influence the choice. (For example, if the limit was four rectifier bays rather than six, then the plant capacity of 2000 amps could not be reached using 4 400-amp capacity rectifiers). Most plants permit mixing of rectifier sizes, but, in order to provide maximum flexibility in the event of a rectifier failure and minimize investment in maintenance spare rectifiers, every effort should be made in adding charge capacity to a plant to maintain the same size rectifiers as those which were originally installed (assuming adequate floor space is available). This, of course, assumes the optimum size rectifier was selected for initial installation. In existing plants, an economic study will indicate the optimum size rectifier(s) which should be used in growing the plant to its capacity. The selection of other than the optimum size rectifiers may result from (1) limited availability of floor space, or (2) avoiding provision of unrequired charge capacity as the plant capacity is reached (as 6 1600-amp and 1 400-amp rectifier for a 10,000-amp plant).

When a power plant is equipped with end cells, special rectifiers are furnished to float and aid in recharging these cells. The various power plant BSP's list the associated end cell chargers and detail their mounting arrangements. Presently the 702C, 708A, 302A, 302B and 303A plants are arranged for end cell operation. The 303A, 702C and 708A plants are engineered initially for the maximum end cell charge requirements. The 302 plants (with up to 10,000 amperes of capacity) have flexible arrangements to furnish an optional number of rectifiers, depending upon the size and quantity of end cell strings in the plant. Two regulated trickle charge rectifiers are provided as standard equipment with the 302A and B main control boards. These two rectifiers are sufficient to handle up to eight strings of L-508 end cells. If the 302 control board is arranged for both 48- and 24-volt operation, two rectifiers are furnished for each voltage.

When more than eight strings of L-508 end cells are needed or when tank-type end cells are used, additional rectifiers are required and are mounted in a separate end cell rectifier bay located next to the main control board if possible. These supplemental rectifiers are usually unregulated with rated output of 12 amperes. One of these rectifiers is sufficient to handle all L-508 end cell strings in excess of eight. When tank-type cells are used, one 12-ampere rectifier is required, in addition to the two regulated rectifiers, for each string of end cells. When it is known initially that additional rectifiers are or will be needed, the supplementary bay is provided and the two regulated rectifiers are mounted on it rather than on the main control board. The power plant BSP lists the equipment codes for these supplemental rectifiers.

6.4 Maintenance Spare Charging Units

From time to time it is necessary to remove a charging unit (M-G or rectifier) from service for either repair or maintenance. When this happens it is imperative that the remaining units be adequate to handle the busy hour load. Therefore, it is necessary to provide spare charging equipment in each power plant equal in capacity to the largest single charging unit. For instance, if a 400-ampere rectifier is the largest single charging unit then 400 amperes of spare charging equipment must be provided. This can either be accomplished by having another single 400-ampere unit or a combination of units having 400 amperes of output.

This policy of providing a maintenance spare rectifier applies to all battery type power plants, regardless of capacity, which permit installation of more than one rectifier.

Certain rectifier power plants, such as the Lorain J1271A-1, do not have battery back-up but utilize converters which operate from the batteries of a different power plant during an AC power failure. If a maintenance spare rectifier (and converter) is provided for in this type of plant, the battery reserve required during a power failure will be increased (the DC input requirement for two converters sharing a load is greater than that of one converter assuming the entire load). In a large office the additional DC input required for the spare converter may not be significant, but in a small office or independent company location it may be. Therefore, unless job conditions warrant, or the reliability of the rectifiers is questionable, a maintenance spare rectifier will usually not be provided in these types of plants.

6.5 Charge Meters, Fuses and Distribution Busses

The standard power plants in use today do not utilize a single charge meter which would reflect the total charge output for the entire plant. Each rectifier is equipped with an individual charge meter and, in order to determine the total charge output of the charging units, it is necessary to add the meter readings of the individual rectifiers. This meter is furnished as a standard part of the rectifier and is sized to handle its maximum output. The individual rectifier BSP's and SD's reference the type and range of the meter.

The output charge leads of a charging unit are fused to protect the control board equipment from being damaged when a charging unit malfunctions. In some of the early plants these fuses were located at the control board, but in the modern rectifier plants the fuse is furnished as part of the rectifier and is sized for the maximum output of the rectifier. This is further discussed in section 6.6 (battery charge fuse).

The leads from the charging units to the main control board may be either cable or bus bar depending upon the size plant. Usually plants with a maximum capacity of 2000 amperes or less will utilize cable. For plants having a maximum capacity above 2000 amperes, cable will be used for capacities of 1200 amperes or less and bus bar above 1200 amperes. When cable is used, separate charge leads are run between the power board and each charging unit. When bus bar is provided, the charging units are tied to a common bus at each charging unit. Bus bar and cabling arrangements for the 111A, 302A, 303A, 702C and 708A power plants are further discussed in BSP 802-005-150. Additional information may be found in the charge and discharge circuits of the various plants.

Copper or aluminum bus bar may be employed in plants with capacities up to 6,000 amps, while copper bus bar will always be used in plants having a capacity of more than 6,000 amps. Aluminum bus should always be used (more economical) if the ultimate plant capacity is 6,000 amps or less. If a smaller plant will eventually be expanded to 8,000 or 10,000 amps, copper bus may be provided initially to avoid the expense of changing out the aluminum bus when the capacity of the plant is expanded to 8,000 amps (space requirements for aluminum bus prohibit its use in 8,000- and 10,000-amp plants). However, the Telephone Company engineer should not specify copper in place of aluminum bus bar unless an 8,000- or 10,000-amp plant will be required in a relatively short period of time and an economic study indicates it is feasible. The three charge busses normally associated with the plants having capacities greater than 1200 amperes are the generator charge (GEN CHG), emergency cell charge (EM CELL CHG), and ground (or charge ground) (GRD). However, a 326A plant has no emergency cell charge busses.

When the charge leads are cable, the Western Electric Company engineer is responsible for sizing them. When the charge leads are bus bar, the Telephone Company engineer is responsible for specifying the minimum bus capacities, although the Western Electric engineer is responsible for detailing the bus bar layout. The Western Electric engineer will size the charge leads according to standard practices unless directed to do otherwise (see part B, section 6.8). The Telephone Company engineer's responsibilities are discussed in detail in part B, section 6.8.

6.6 Power Boards

The power boards are used to mount the various controls and distribution equipment required to operate a power plant. Standard layouts of these floor-mounted bays locate them in close proximity to the charge equipment and batteries. Fuse, switch and control equipment panels are mounted on the framework and unused positions are normally covered with blank panels. The power board framework also supports the associated cable racks and bus bars.

In smaller power plants (see figure 6.4) the charge controls, meters and distribution fuses may all be located in one control bay. Subsequent additions of charge equipment may or may not require the addition of a supplementary control bay. In larger offices (see figure 6.5), more than one bay is usually required to mount this same equipment.

The following types of bays are provided in most plants:

Main control bay - In most small plants, all control and distribution equipment is mounted in a main control bay (see figure 6.4). In some larger plants not having emergency or counter cells, all control equipment is mounted in one main control bay, but separate distribution bays are provided. In other large plants (see figure 6.5), a separate main control bay is provided to mount the various voltage control and alarm relays together with the fuses, lamps and keys associated with these circuits. Emergency cell trickle chargers may also be located on this bay.

Battery control bay - This bay, when provided in larger plants (see figure 6.5), mounts the emergency cell switch, emergency cell charge switch, main battery charge fuse (if provided) and the discharge ammeter and voltmeters.

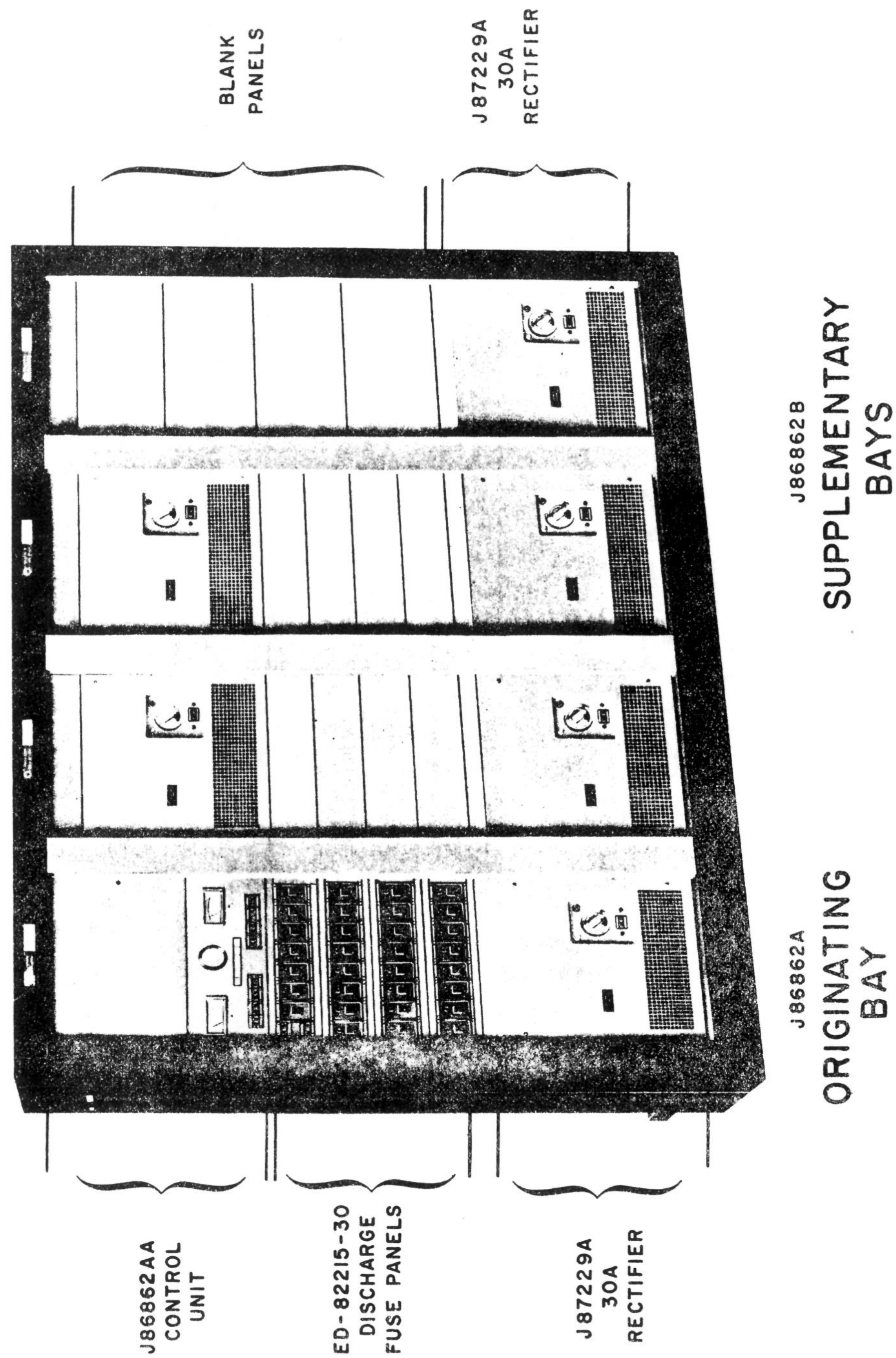


Figure 6.4 - Typical Power Board Arrangement - Small Office

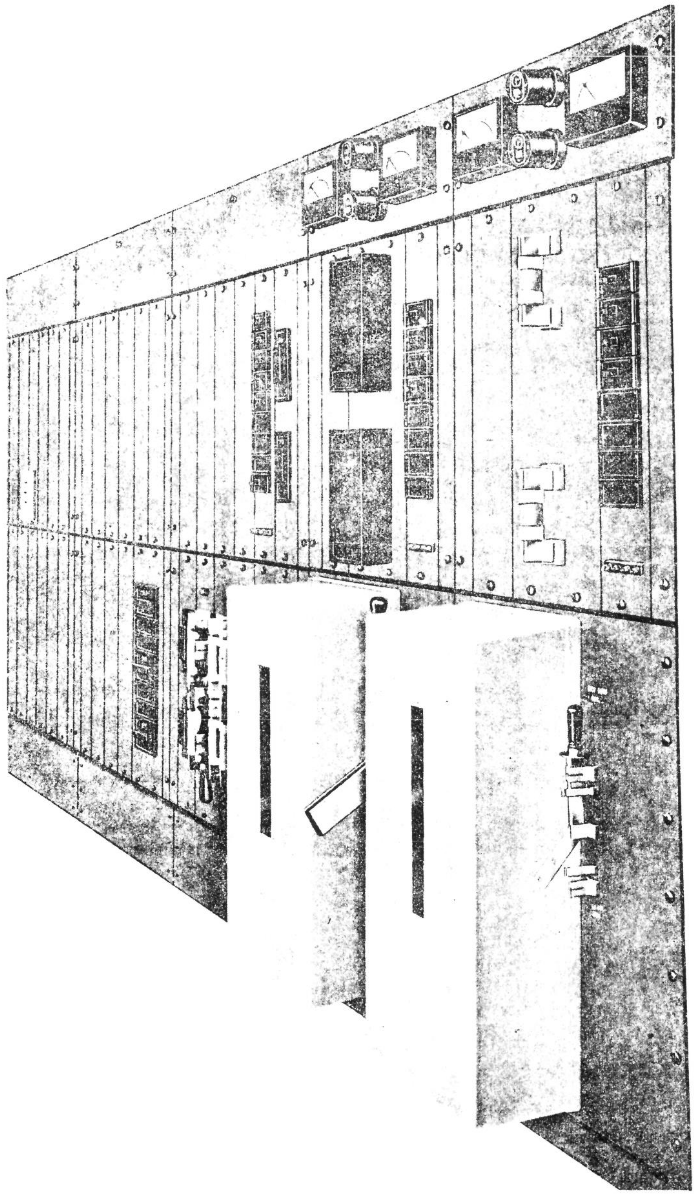


Figure 6.5 - Typical Power Board Arrangement - Large Plant

Battery distribution fuse bays - In larger offices, separate battery distribution fuse bays are provided for mounting the discharge fuses through which the various office loads are fed.

Regardless of the size of office, the power boards serve as a centralized distribution point for tying together charge unit outputs, battery leads and load distribution feeders.

The following major components may, depending upon the type of plant, be located in the power boards:

Emergency cell switch - A typical emergency (or end) cell layout is shown in figure 6.6. The emergency cell switch may be manual or motor-dirven and is used to switch emergency or end cells in and out of the circuit depending upon discharge voltage requirements.

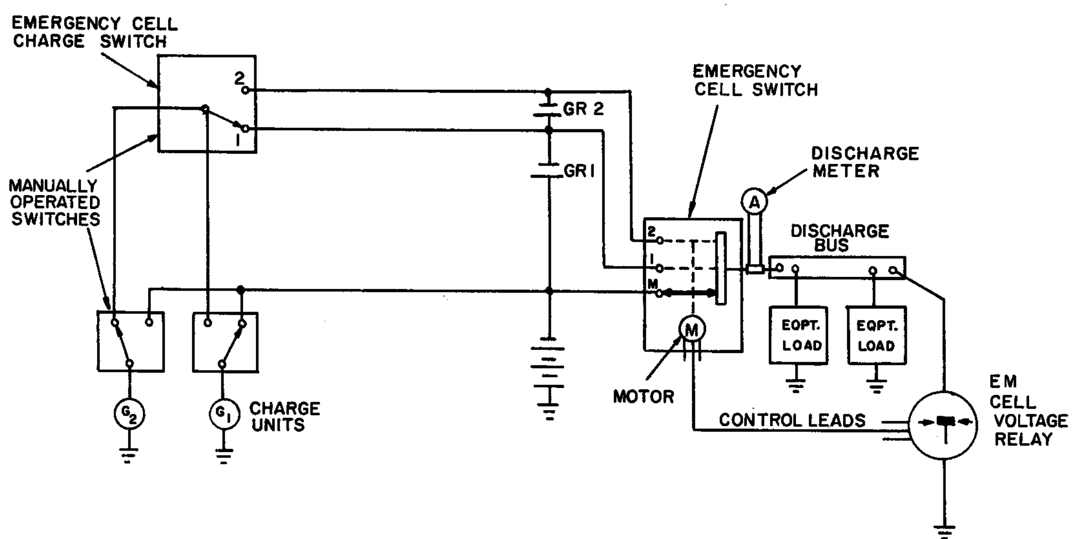


Figure 6.6 - Emergency Cell Operation Employing Charge by Load Method

Emergency cell voltage relay - This relay, which has adjustable high and low voltage operating limits, controls operation of the motor which drives the emergency cell switch (see figure 6.6).

Emergency cell charge switch - Since emergency cell trickle charge rectifiers have very limited capacity they are unable to bring emergency cells back to full charge after a substantial discharge. High charge rates can be applied to emergency cells by a method known as "charge by load" (see figure 6.6). This is accomplished by placing one charge unit on manual operation, throwing the switch on that unit to the EM CELL position (G2 in figure 6.6) and then operating the end cell charge switch to either position 1 or 2. The output of this rectifier is then available for both recharging the emergency cells and distribution to the load.

Discharge ammeter and voltmeter - These meters record the voltage and ampere drain of the discharge load. In some plants a total office discharge ammeter reading may be obtained. In others, separate discharge ammeters are provided for each discharge load (there may be more than one). In yet other plants, no discharge ammeters are provided and the outputs of the individual charge units must be added together in order to estimate the discharge load. Recording ammeters should be provided in variable-load plants to permit minimum-cost, 24-hour drain studies.

Countercell contactors and controls - Contactors (see figure 6.7) are used to switch countercells in and out of the distribution circuit (see section 7.5 for a discussion of countercell operation). The term contactor is used to designate a type of relay that can safely conduct high currents through its contacts. Voltage monitoring relays are used to control the operation of the contactor.

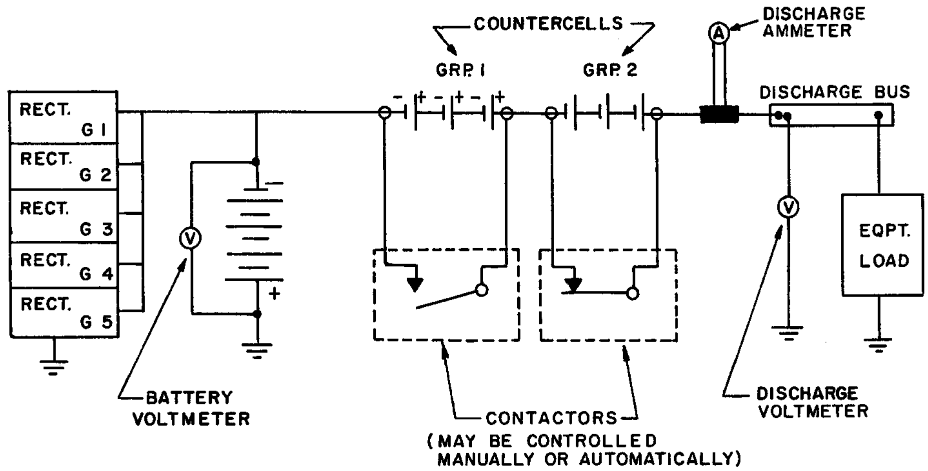


Figure 6.7 - Countercell Operation

Battery charge fuse - This fuse, sometimes referred to as the charge fuse, was provided in some of the older, large plants to protect the charge leads (see figure 6.8). This fuse is no longer provided on new plants and, if possible, is being removed on existing plants when they are modified for increased capacity. The battery charge fuse must be left in place if motor - generator sets are being utilized in the plant since the motor - generator sets are not equipped with internal charge lead protection.

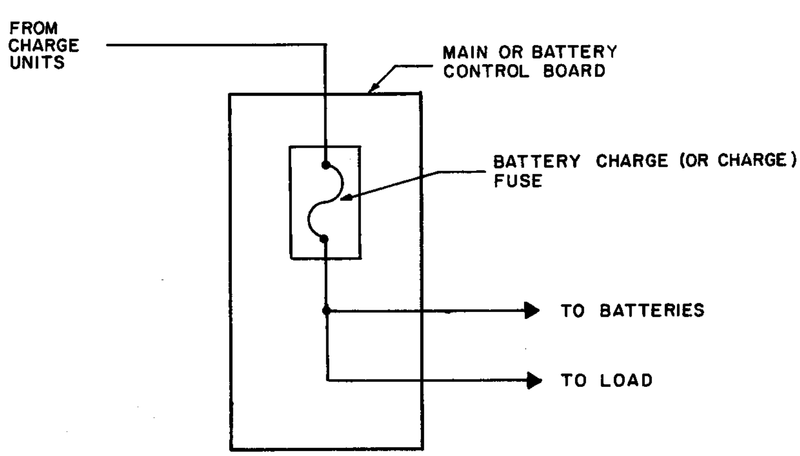


Figure 6.8 - Battery Charge Fuse

Main discharge fuses - The main discharge fuses, located on the main control or battery distribution fuse bays, feed the primary equipment power distribution bays (BDFB in SXS, PRTD in No. 5, PDF in No. 1 ESS, etc.), equalization centers or equipment bays (in smaller offices). Most plants employ either a knife switch fuse holder or a saftofuse mounting. The knife switch mounting permits selection between one of two fuses assigned to a distribution circuit. This arrangement, shown in figure 6.9, provides the necessary service protection if a fuse is blown or in need of replacement. When fuse 1 is blown, the switch may be thrown to position 2, thereby placing fuse 2 in the circuit and permitting replacement of fuse 1. Knife switch mountings are provided for all fuses having a capacity of more than 200 amps. For most plants, single saftofuse units are provided for fusing requirements up to 200 amps. In certain new plants (as the 326A), a new type of switch unit employing saftofuse units is being used to provide the same type of protection shown in the arrangement of figure 6.9. In some small plants, distribution may be fed through 70-type fuses (see section 6.7) rather than small saftofuse units. Details of a saftofuse mounting can be seen in figures 1 and 2 of BSP 026-370-701.

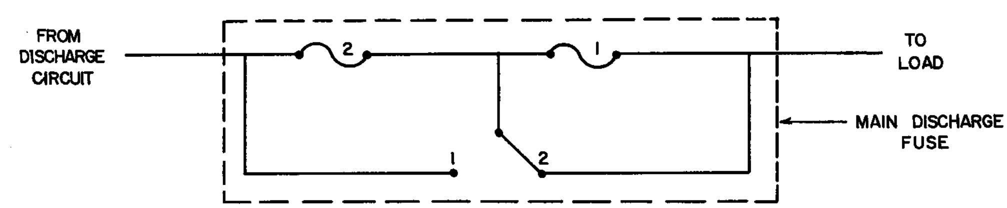


Figure 6.9 - Main Discharge Fuse, Large Plant

Specific arrangements of the power boards for each power plant are covered in the BSP's and equipment drawings for the plant. Those items in each plant requiring an engineering decision are outlined in part B, section 2.3.

6.7 Discharge Distribution System

The discharge distribution system is comprised of batteries, battery leads, countercells or emergency cells (see figures 6.4 and 6.5), fuses, bays and leads feeding equipment fuse panels from the main discharge fuses (see figure 6.10).

The leads from the power boards to the batteries and/or emergency cells may be either cable or bus bar depending upon the size plant. Usually plants with a capacity of up to 1200-2000 amps utilize cable for these leads while larger plants will employ bus bar. Copper or aluminum bus bar may be employed in plants with capacities up to 6000 amps, while copper bus bar will always be used in plants having a capacity of more than 6000 amps. Aluminum bus should always be used (more economical) if the ultimate plant capacity is 6000 amps or less. If a smaller plant will eventually be expanded to 8,000 or 10,000 amps, copper bus may be provided initially to avoid the expenses of changing out the aluminum bus when the capacity of the plant is expanded to 8,000 amps (space requirements of aluminum bus prohibit its use in 8,000- and 10,000-amp plants). However, the Telephone Company engineer should not specify copper in place of aluminum bus bar unless an 8,000- or 10,000-amp plant will be required in a relatively short period of time and an economic study indicates it is feasible. Since counter cell use is limited to small plants or small, individual discharge loads, leads to them will always be cable. Those items in the distribution system requiring engineering decisions are outlined in part B, section 2.3 and are usually limited to bus bar sizing. Bus bars must be capable of handling the ampere load while not exceeding voltage drop limitations established for the circuit. These limitations are outlined on the SD drawing for the discharge circuit. Most bus bar in the discharge distribution will be sized by the Western Electric engineer to match the discharge capacity of the plant unless the Telephone Company engineer specifies otherwise. All cable leads are sized by the Western Electric engineer to meet current carrying and voltage drop requirements. See section 6.8 for details concerning bus bar sizing.

Provision of all equipment necessary for feeding power to telephone equipment from the main discharge fuses is the responsibility of the Western Electric engineer except as noted in the following paragraphs of this section.

In certain power plants, the discharge system is divided into separate and distinct loads with each load having a specific discharge drain capacity. The Telephone Company engineer is responsible for specifying both the size and number of discharge loads when more than one arrangement is available in a particular plant. Those plants having separate discharge loads and requiring this engineering decision are listed in item 15 of figure 2.5, part B, section 2.0.

As shown in figure 6.10 a main discharge fuse may serve (via cabled leads) a main distribution fuse bay (the name used for this bay will depend upon the system: battery distributing fuse bay or BDFB in SXS; power and ringing tone distribution or PRTD bay in No. 5 Crossbar; power distributing frame in No. 1 ESS, etc.). This bay will usually employ smaller 35- or 70-type fuses for distributing power to various equipment fuse panels located in either separate fuse bays or in the equipment bays themselves. When blown, these 35- or 70-type fuses will activate a fuse alarm.

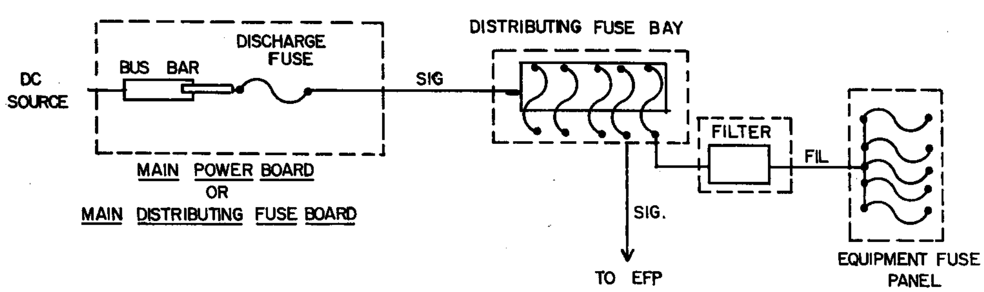


Figure 6.10 - Typical Discharge Distribution Arrangement

Precautions are necessary in power plant wiring to minimize the noise induced in telephone circuits. To minimize noise, conductors are paired to neutralize their inductive effect. Talking (quiet) battery leads and signaling battery leads are run separately at specified distances apart. Conductors carrying ringing, tone and other high and low frequency AC currents having high voltage peaks including service circuits, are run in armored cable or conduit. In addition, leads which feed amplifiers are shielded since any induced noise would be amplified along with the voice current.

The direct current required in a central office falls into two general classes: signaling battery, which is used to operate all the various types of electromechanical apparatus such as relays, etc., and talking battery which supplies the medium for voice transmission. (The various types of talk and signal drains are outlined and defined in BSP 802-005-180). Since practically all equipment for generating direct current introduces ripples or noise in their output, it is necessary that battery filters be used to keep such disturbances to a minimum. Figure 6.11 indicates graphically the effect of a filter on an irregular wave form having high frequency ripples or noise. Battery filters (which are required for all talk battery circuits) consist essentially of inductors and capacitors. Large common filters, formerly located in the power room, are being replaced by the decentralized type which are mounted on relay rack bays, fuse bays, cable racks, on top of frames, and in switchboard turning sections, as required. The use of decentralized filters makes unnecessary separate power cable runs for signal and talking battery between the power plant and the various frames. This not only results in a saving in power cables but also improves the troublesome noise and crosstalk exposure encountered with former common filter arrangements. Decentralized filtering is presently being provided in all offices on a next-job basis. In larger offices, the change to decentralized filters may be spread over two or three jobs to minimize capital requirements.

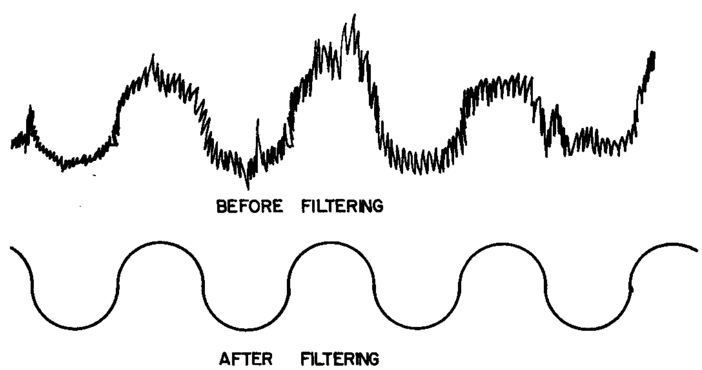


Figure 6.11 - Effect of a Filter on an Irregular Wave Form

Certain equipment systems utilize equalization centers to minimize requirements for distribution fuse bays located in equipment rooms. Figure 6.12 shows a typical equalization center arrangement in a No. 5 crossbar office.

Main feeders from main discharge fuses (shown in sketch C of figure 6.12) are run to centralized distribution points, called equalization centers. Parallel cable connectors, referred to as equalizers, are used to connect these main feeders to individual equipment aisle feeders. Each aisle feeder is fused in a cabinet mounted on the end guard of the first bay in the aisle. Leads run to the individual equipment bays are half-tapped from these aisle feeders. The capacities and engineered drain for each equalization center are reflected on the Western Electric T drawing for the power distributing circuit (see figure 6.13).

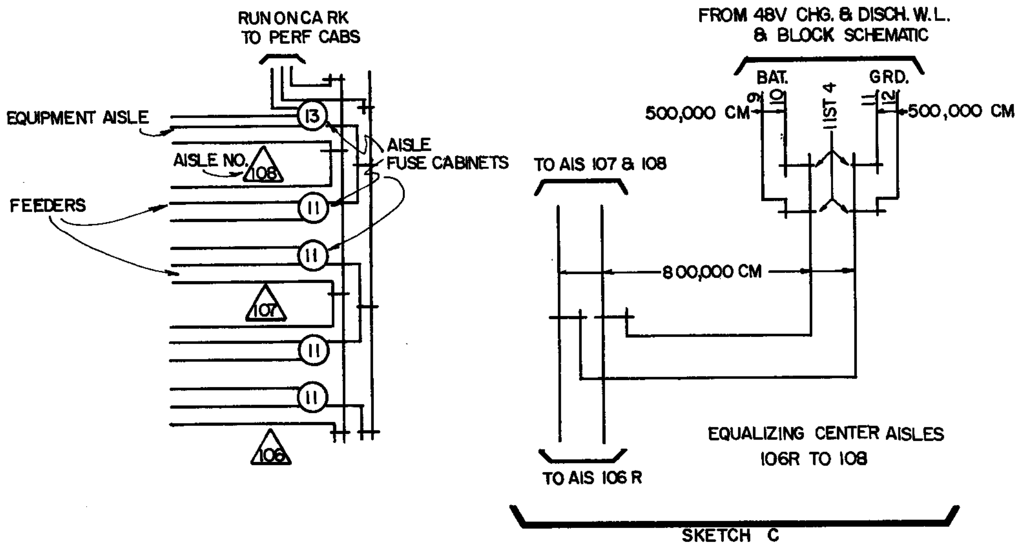


Figure 6.12 - Typical Equalization Center Arrangement

In certain equipment systems, as No. 5 and No. 4 crossbar, equalization centers are provided as part of the standard office layout. All layout and sizing decisions are made by the Western Electric engineer subject to Telephone Company engineering approval.

Use of equalization centers will prove to be more economical wherever a large, concentrated power requirement exists, as in carrier equipment lineups. The decision to use equalization centers in these instances lies with the Telephone Company engineer. The Western Electric power engineer should be consulted to determine if the arrangement is feasible and, in many cases, the Western Electric engineer may actually suggest use of equalization centers.

6.8 Sizing Bus Bars

Installation and assembly of bus bars is discussed in BSP 802-005-180. The following charge busses are usually found in bus bar plants: generator charge, emergency cell charge and ground (charge ground). The following discharge busses are usually found in bus bar plants: battery charge, battery-, emergency cell group 1, emergency cell group 1 & 2, and discharge ground.

AISLE FEEDERS

TABLE A

CUMULATIVE FRAME LINEUP DRAIN CALCULATIONS

AISLE		INITIAL	ADDITIONAL		AISLE		INITIAL	ADDITIONAL	
100R	BAT	-			106L	BAT	132.0		
	GRD	-				GRD	236.5		
101L	BAT	4.5	17.04		106R	BAT	26.4	31.5	45.4
	GRD	4.5	17.04			GRD	-	1.5	5.5
101R	BAT	42.0			107L	BAT	31.5	49.1	57.9
	GRD	75.3				GRD	1.5		4.0
102L	BAT	32.7	65.4	76.8	107R	BAT	-	10.2	
	GRD	15.7	31.4	37.8		GRD	2.3	5.3	
102R	BAT	42.7	67.7		108L	BAT	15.5		
	GRD	26.7	39.7			GRD	7.7		
103L	BAT	74.6	92.0		108R	BAT	15.5	20.8	25.9
	GRD	87.2	102.5			GRD	7.7	12.4	13.9
103R	BAT	159.4							
	GRD	156.4							
104L	BAT	23.6	49.8	105.4					
	GRD	28.1	61.5	119.9					
104R	BAT	22.6							
	GRD	38.3							
105L	BAT	36.2	47.1	52.1					
	GRD	73.5	79.0	84.5					
105R	BAT	30.0	50.0	55.9					
	GRD	33.0	55.0	55.0					

EQUALIZATION CENTER

SUMMARY OF CURRENT DRAIN DATA **TABLE B**

T-4H06-01 ISS 2 FLOOR PLAN

CIRCUIT		FUSE	LEAD SIZE	LENGTH FEET	MAX (1)	INITIAL (2)	CUMULATIVE TOTAL DRAIN FOR FRAMES ADDED ON ORDER 78480	66032	7-76808	67049		
AIS 100-103	BAT	300	2-500,000CM	92	400	317.6	411.2	412.7	417.74	455.64		
	GRD	–	2-500,000CM	85	530	297.9	418.4	419.9	424.94	445.84		
AIS 104-106L	BAT	600	2-500000CM	75	400	247.6	395.3	395.3	395.3	395.3		
	GRD	–	2-500000CM	68	600	404.3	589.9	589.9	589.9	589.9		
AIS 106R-108	BAT	600	2-500,000CM	65	400	91.7	170.2	170.2	170.2	170.2		
	GRD	–	2-500,000CM	58	600	28.8	51.0	51.0	51.0	51.0		

(1) MAX PEAK DRAINS LEADS CAN CARRY WITHOUT EXCEEDING ALLOWABLE VOLTAGE DROP OR CURRENT LIMITATION ON FUSE.

(2) PEAK DRAIN OF ALL FRAMES ADDED PER ISSUE OF FLOOR PLAN DRAWING.

Figure 6.13 - Typical Equalization Center, Capacities and Engineered Drains

Unless otherwise specified by the Telephone Company engineer, the charge busses will be sized by the Western Electric Company engineer to handle the greater of either (1) the total installed charging capacity of the power plant or (2) the capacity of the emergency cell switch. The discharge busses will normally be engineered by the Western Electric Company engineer to handle the capacity of the emergency cell switch.

Because of the difficulties and expense involved in both initial installation and rearrangement of bus bars, it may be advisable to engineer the charge busses for some other capacity than would result from application of (1) or (2) above. For example, assume a new plant is to be installed and equipped with four 800-ampere rectifiers (3200 amperes total charging capacity) and a 6,000-ampere emergency cell switch. Using the criteria established in (1) and (2), the charge busses would be engineered to handle a minimum of 6,000 amperes. Let's also assume that the power data indicates only two additional 800-ampere rectifiers will be required during the next 6 years. In this case, the Telephone Company engineer might specify that the charge busses be engineered to handle a maximum of 4,800 rather than 6,000 amperes. This decision should, of course, be based on economics. Generally, if the size of the installed emergency cell switch is large in comparison to the installed charge capacity, it is usually more economical to specify that a smaller charge bus be installed initially (than would normally be provided by Western Electric engineering) and provide for reinforcement at some later date. Consideration must also be given to the point at which an emergency cell switch will be changed to a capacity greater than 6000 amperes, thereby requiring the bus bars to be changed from aluminum to copper.

As stated earlier, the discharge busses are usually engineered to match the capacity of the emergency cell switch. There may, however, be an occasion where the emergency cell switch capacity will not be reached for a long period of time and it would be more economical to initially engineer the discharge busses for some smaller capacity. For example, assuem a 4000-ampere capacity switch is being installed, but a review of the forecasted drain requirements indicates the drain will not exceed 2,500 amperes for ten years. In this case, the Telephone Company engineer should specify that the discharge busses be engineered initially for 2,500 amperes with provision to expand them to 4,000 amperes at a later date.

When increasing the capacity of an existing power plant, the Telephone Company engineer is responsible for verifying the adequacy of the existing charge and discharge busses and to provide for increasing the capacity of the busses if found to be inadequate. The cost of bus bar is a major estimate item and omission from estimated expenditures may result in a deficit of supplemental proportions. It is especially critical to know when aluminum bus bar must be replaced with copper. Not only is the copper bus bar expensive, but the associated estimate must provide for the removal and retirement of the aluminum bus bar since it is a unit of property.

The Western Electric office drawings will include a layout of the bus bar arrangements if a power plant is equipped with bus bar. These drawings detail the makeup of the bars and provide cross-sectional views which outline the size, the quantity and the type of material (aluminum or copper) for the bus bars. Section 16:22 of the Power Data book lists the current carrying capacities of the various bus bar cross sections. Figure 6.14 shows a portion of this section. To illustrate the steps required in determining bus bar capacities, assume a cross-section shows an aluminum bus bar horizontal run (figure 6.15) to consist of 8 bars, each ¼ inch by 6 inches. Figure 6.14 shows the current carrying capacity to be 8804 amperes. If the bars were copper rather than aluminum, the capacity would be 11,645 amperes. When bus bars are run vertically, the current carrying capacity is reduced because heat cannot be dissipated as readily as on a horizontal run. As can be seen in figure 6.14 the Power Data book lists the current carrying capacities for both horizontal and vertical runs. In order to reduce the number of bars required in a vertical run, it is permissable to use copper bars in conjunction with horizontal aluminum bars.

If an investigation reveals that a bus run is not adequate for a planned addition, the Telephone Company engineer must decide what steps should be taken to increase the capacity. In some instances, all that may be required is addition of laminations to an existing bar; in other cases, it may be necessary to replace the entire run with bars of different sizes or material. In reviewing alternatives, it may be appropriate to consult with the Western Electric Company engineer and, if necessary, arrange for an on-site meeting.

6.9 Sizing Emergency Cell Switches

The capacity of an existing emergency cell switch should be sufficient to handle the projected discharge drain for the end of the power engineering period.

If a new power plant is being installed or an existing switch is being replaced, the new switch should normally be sized to handle discharge drain requirements for a minimum of eight years. Consideration must be given, however, to the growth characteristics of the office and the possible future relocation of the power plant. Where more than one reasonable alternative for sizing is apparent, an economic study (similar to that outlined in part B, section 2.2) may be warranted.

In some plants (as the 303A), the minor cost difference between various sizes of emergency cell switches justify initial installation of the maximum size switch regardless of projected discharge drain requirements. If a switch other than the maximum size available with a plant is specified for installation (either as part of a new plant or as a replacement for an existing switch), sufficient floor space should be reserved for future installation of the largest switch available with the plant. Western Electric engineering should also be instructed to lay out bus bar runs, distribution bays, etc., keeping in mind that ultimate replacement of the smaller bay is contemplated. Of course, this need not be done if replacement or relocation of the entire plant is contemplated before this maximum capacity would ever be reached.

Horizontal Runs

Vertical Runs

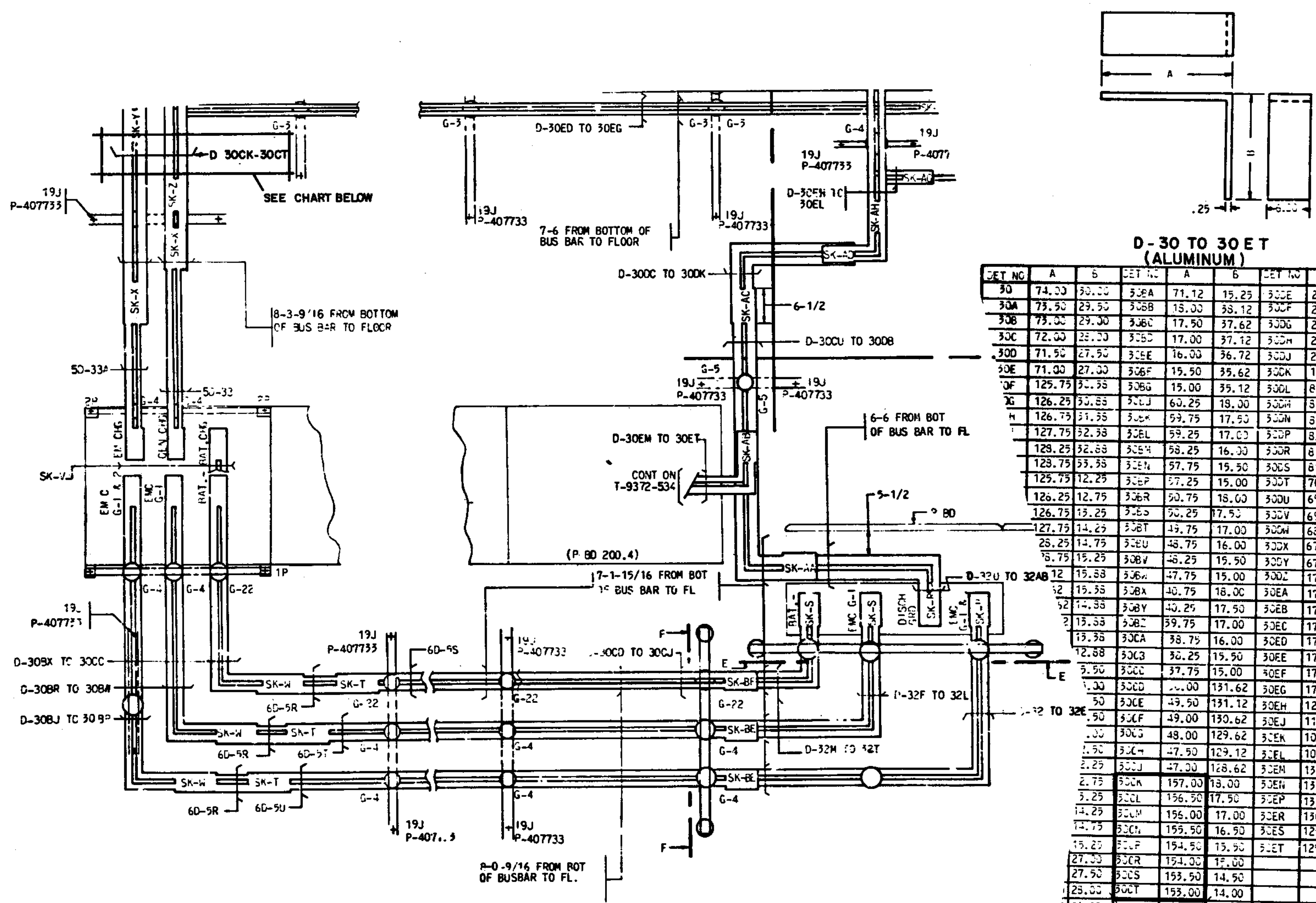
NO. OF BARS	THICK-NESS (INCHES)	WIDTH (INCHES)	AREA IN CM (THDS.)	ALUMINUM (SEE NOTE 5) AMPACITY SEE NOTE 2	ALUMINUM AMPACITY SEE NOTE 3	ALUMINUM LBS PER FT.	ALUMINUM MICROHMS PER FT. @70 C	COPPER AMPACITY SEE NOTE 2	COPPER AMPACITY SEE NOTE 3	COPPER LBS PER FT.	COPPER MICROHMS PER FT. @70 C
7	1/4	6	13,370.0	7753	6041	12.32	1.62	10270	8076	40.60	0.95
		8	17,822.0	9926	6878	16.38	1.21	13150	9259	54.11	0.71
8	1/4	6	15,280.0	8804	6808	14.08	1.42	11645	9086	46.40	0.83
		8	20,372.0	11265	7711	18.72	1.06	14905	10360	61.84	0.62
9	1/4	6	17,190.0	9854	7575	15.84	1.26	13020	10095	52.20	0.74
		8	22,914.0	12605	8541	21.06	0.94	16660	11455	69.57	0.55
10	1/4	6	19,100.0	10905	8338	17.60	1.13	14400	11100	58.00	0.67
		8	25,460.0	13945	9369	23.40	0.85	18415	12545	77.30	0.49
11	1/4	6	21,010.0	11955	9102	19.36	1.03	15775	12105	63.80	0.60
		8	28,006.0	15285	10195	25.74	0.77	20170	13640	85.03	0.45
12	1/4	6	22,920.0	13005	9866	21.12	0.94	17150	13110	69.60	0.55
		8	30,560.0	16625	11025	28.08	0.71	21925	14725	92.86	0.41
2	1/2	2	2,546.0	1458	1411	2.34	8.49	1961	1902	7.72	4.98
		3	3,820.0	2015	1906	3.52	5.66	2715	2577	11.60	3.22
		4	5,093.0	2555	2346	4.68	4.24	3445	3182	15.46	2.49
		6	7,639.0	3597	3131	7.04	2.83	4861	4275	23.20	1.66
		8	10,186.0	4608	3770	9.38	2.12	6236	5189	31.92	1.25
3	1/2	4	7,640.0	3670	3291	7.02	2.83	4918	4437	23.19	1.66
		6	11,460.0	5146	4311	10.56	1.88	6902	5848	34.77	1.11
		8	15,280.0	6572	5083	14.07	1.42	8824	6950	46.38	0.831
4	1/2	4	10,186.0	4782	4228	9.36	2.12	6384	5679	30.92	1.35
		6	15,280.0	6688	5473	14.08	1.42	8933	7392	46.36	0.831
		8	20,372.0	8527	6362	18.76	1.06	11395	8659	61.84	0.623
5	1/2	4	12,730.0	5892	5161	11.70	1.69	7847	6915	38.65	0.997
		6	19,100.0	8227	6626	17.60	1.13	10960	8921	57.95	0.665
		8	25,460.0	10475	7624	23.45	0.849	13960	10340	77.30	0.498
6	1/2	4	15,280	7002	6092	14.04	1.42	9309	8148	46.38	0.831
		6	22,920.0	9765	7775	21.12	0.943	12980	10445	69.54	0.554
		8	30,560.0	12425	8876	28.14	0.707	16520	12005	92.76	0.415
7	1/2	6	26,740.0	11300	8921	24.64	0.808	15000	11960	81.13	0.475
		8	35,644.0	14345	10120	32.83	0.606	19080	13660	108.22	0.356
8	1/2	6	30,560.0	12840	10065	28.16	0.707	17020	13475	92.72	0.415
		8	40,744.0	16320	11365	37.52	0.530	21635	15310	123.68	0.313
9	1/2	6	34,380.0	14375	11205	31.68	0.629	19040	14985	104.31	0.369
		8	45,828.0	18265	12605	42.21	0.472	24190	16955	139.14	0.277
10	1/2	6	38,200.0	15910	12350	35.20	0.566	21060	16495	115.90	0.332
		8	50,920.0	20210	13840	46.90	0.424	26745	18600	154.60	0.248

NON-PREFERRED

NOTES:

1. VOLTAGE DROP = RES./FT. @ 70 C X AMPERES X FT. (LOOP).
2. AMPACITY RATINGS BASED ON 30 C RISE ABOVE 40 C AMBIENT, BARS WITH LONG AXIS VERTICAL, SPACING BETWEEN BARS EQUAL TO OR MORE THAN THE THICKNESS OF THE BARS; AND BARS RUN IN A HORIZONTAL PLANE.
3. AMPACITY RATINGS TO BE USED WHEN THE AMBIENT TEMPERATURE EXCEEDS 40 C, OR WHEN THE LONG AXIS OF THE BARS IS IN THE HORIZONTAL PLANE, OR WHEN THE SPACING BETWEEN BARS IS LESS THAN THE THICKNESS OF THE BARS, OR WHEN THE BARS ARE RUN IN A VERTICAL DIRECTION.
4. MINIMUM BENDING RADII IS EQUAL TO TWICE THE THICKNESS OF THE BAR FOR ALUMINUM AND EQUAL TO THE THICKNESS OF THE BAR FOR COPPER. TO PREVENT SURFACE ROUGHENING, IT IS RECOMMENDED THAT THE BENDING RADII FOR 1/8 INCH AND 1/4 INCH BARS BE 2 TIMES THE MINIMUM BENDING RADII AND FOR 3/8 INCH AND 1/2 INCH 2-1/2 TIMES THE BENDING RADII.
5. ALUMINUM BUS BAR IS 6101-T6 TYPE C ALLOY PER ASTM B-317.

Figure 6.14 - Bus Bar Capacities, Power Data Book



D-30 TO 30ET
(ALUMINUM)

DET NO	A	B	DET NO	A	B	DET NO	A	B
30	74.00	30.00	30BA	71.12	15.25	30DE	22.75	14.00
30A	73.50	29.50	30BB	18.00	38.12	30DF	22.25	13.50
30B	73.00	29.00	30BC	17.50	37.62	30DG	21.25	12.50
30C	72.00	28.00	30BD	17.00	37.12	30DH	20.75	12.00
30D	71.50	27.50	30BE	16.00	36.72	30DJ	20.25	11.50
30E	71.00	27.00	30BF	15.50	35.62	30DK	19.75	11.00
OF	125.75	30.38	30BG	15.00	35.12	30DL	84.00	12.00
G	126.25	30.88	30BJ	60.25	18.00	30DM	83.50	11.50
H	126.75	31.38	30BK	59.75	17.50	30DN	83.00	11.00
	127.75	32.38	30BL	59.25	17.00	30DP	82.00	10.00
	128.25	32.88	30BM	58.25	16.00	30DR	81.50	9.50
	128.75	33.38	30BN	57.75	15.50	30DS	81.00	9.00
	125.75	12.25	30BP	57.25	15.00	30DT	70.00	18.00
	126.25	12.75	30BR	50.75	18.00	30DU	69.50	17.50
	126.75	13.25	30BS	50.25	17.50	30DV	69.00	17.00
	127.75	14.25	30BT	49.75	17.00	30DW	68.00	16.00
	28.25	14.75	30BU	48.75	16.00	30DX	67.50	15.50
	8.75	15.25	30BV	48.25	15.50	30DY	67.00	15.00
	12	15.88	30BW	47.75	15.00	30DZ	177.12	12.00
	52	15.38	30BX	40.75	18.00	30EA	176.62	11.50
	52	14.88	30BY	40.25	17.50	30EB	175.62	10.50
	2	15.38	30BZ	39.75	17.00	30EC	175.12	[illegible]
		15.38	30CA	38.75	16.00	30ED	177.88	12.00
		12.88	30CB	38.25	15.50	30EE	177.38	11.50
		5.50	30CC	37.75	15.00	30EF	176.38	10.50
		.00	30CD	[illegible]	131.62	30EG	175.88	10.00
		50	30CE	49.50	131.12	30EH	12.00	12.00
		.50	30CF	49.00	130.62	30EJ	11.50	11.50
		.00	30CG	48.00	129.62	30EK	10.50	10.50
		.50	30CH	47.50	129.12	30EL	10.00	10.00
		.25	30CJ	47.00	128.62	30EM	132.00	12.00
		.75	30CK	157.00	18.00	30EN	131.50	11.50
		.25	30CL	156.50	17.50	30EP	131.00	11.00
		14.25	30CM	156.00	17.00	30ER	130.00	10.00
		14.75	30CN	155.50	16.50	30ES	129.50	9.50
		15.25	30CP	154.50	15.50	30ET	129.00	9.00
		27.00	30CR	154.00	15.00			
		27.50	30CS	153.50	14.50			
		28.00	30CT	153.00	14.00			
		29.00	30CU	56.00	15.50			
30AR	155.50	29.50	30CV	55.50	15.00			
30AS	159.00	30.00	30CW	55.00	14.50			
30AT	93.75	13.25	30CX	54.50	14.00			
30AU	92.75	12.25	30CY	53.50	13.00			
30AV	68.12	12.25	30CZ	53.00	12.50			
30AW	196.12	12.75	30DA	52.50	12.00			
30AX	196.62	13.25	30DB	52.00	11.50			
30AY	197.62	14.25	30DC	23.75	15.00			
30AZ	70.62	14.75	30DD	23.25	14.50			

Figure 6.15 - Typical Bus Bar Layout

6.10 Engineering Responsibilities

The decisions which must be made by the Telephone Company engineer in engineering the charge and discharge equipment are summarized in part B, section 2.3.

In addition, the following decisions may also be required and are the responsibility of the Telephone Company engineer:

- Are decentralized filters required? Will they be installed on one job or spread over two or three jobs to reduce capital requirements? See part B, section 6.7.
- Will equalization centers be utilized? See part B, section 6.7.

6.11 Charge and Discharge Equipment Entries, SWX-XXXX-550-G Drawing

The charge and discharge sections of the SWX-XXXX-550-G drawing (section III) are shown in figure 6.16.

- Part III A-C: entries for the present and power engineering period dates should be made using procedures and references outlined in part B, section 7.7.
- Part III D: capacities of those applicable items should be shown in this section. N/A should be shown under the appropriate columns if the item is not required in the installed plant (see figure 6.16). Procedures outlined in part B, section 6.8 should be used in determining bus bar capacities.
- Part III E: the capacities of the rectifiers installed at the end of the power engineering period should be shown in this section (see figure 6.16).

D. BUS BAR, SWITCH AND FUSE CAPACITIES

ITEM	CAPACITY-AMPS	
	PRES	PWR E.P
EMERGENCY CELL SWITCH	N/A	N/A
DISCHARGE METER, LOAD A	150	150
DISCHARGE METER, LOAD B	150	150
DISCHARGE METER, LOAD C	500	500
BATTERY CHARGE FUSE	N/A	N/A
BUS BAR CHARGE GROUND		

	ITEM	CAPACITY-AMPS	
		PRES	PWR E.P
BUS BAR	GENERATOR CHARGE	N/A	N/A
	EMERGENCY CELL CHARGE		
	DISCHARGE GROUND		
	BATTERY		
	EM CELL GROUP 1		
	EM CELL GROUP 1 + 2		

E. RECTIFIERS AND MOTOR GENERATORS, END OF POWER ENGINEERING PERIOD

TYPE		INST. SPEC	DC CAP [2]
J87233A	LOAD A	4431.22	30
J87233A			30
J87233A			30
J87233A			30
J87233A	LOAD B	4431.45	30
J87233A			30
J87233A			30

TYPE		INST. SPEC	DC CAP [2]
J87233A	LOAD B	4431.104	30
J87233C	LOAD C		100
J87233C			100 [1]
TOTAL CHARGE CAP. LESS MAINT SPARE			

NOTE: [1] INDICATES MAINTENANCE SPARE WHICH (IS)(~~IS NOT~~) ARRANGED FOR AUTOMATIC OPERATION.

[2] IF CAPACITY STATED AS CONTINUOUS AND INTERMITTENT, RECORD CONTINUOUS CAPACITY.

Figure 6.16 - Charge and Discharge Equipment Entries, SWX-XXXX-550-G Drawing

6.12 Calculation of Lead and Fuse Sizes

As discussed in part B, section 4.3, List 1 drains are used in sizing the major components of a power plant. However, List 2 drains are used to calculate the size power conductor necessary to carry the circuit current while guarding against any excessive voltage drop which might affect circuit operation. List 2 drains are also used to size circuit fuses to provide adequate protection. So-called "safety" factors are used in making these lead and fuse size determinations.

What are List 2 drains and how do they differ from List 1 drains? Studies conducted by the Bell Labs in 1941 reached the following conclusions:

1. Voltage drops and, in turn, lead sizes as related to voltage drops should be calculated on current values representing about 75% of the full load current taken by the equipment.
2. Fuse sizes and, in turn, lead sizes as related to current carrying capacity should be calculated on current values representing about 110% of the full load current.

These figures were substantiated by extensive field experience and result in adequate leads and fuses at a reasonable cost. The direct approach, therefore, would be to publish full load figures for List 2 and apply the factors previously mentioned. However, there are other safety factors in use by Western Electric which also must be considered. These factors are covered by standard power plant calculation drawings (as SD-80965-01 for 300 type plants) and call for List 2 drains to be modified as follows:

A. The so-called "circuit peak" is equal to 133% of the List 2 value. This figure is used for calculating lead size from a voltage drop basis.

B. For calculating lead sizes and fuses from a current carrying standpoint a value equal to 150% of the "circuit peak" value is used, or 200% of the List 2 value.

Obviously, the application of the standard factors A and B to full load List 2 figures would not result in the engineering objectives cited under 1 and 2. Therefore, in order to gain objectives 1 and 2 and still use the standard Western factors A and B, a compromise value for List 2 is used. This is equal to $\frac{2000}{3600}$ X full load value and is always used in calculating List 2 tables. It is easily seen that

$\frac{2000}{3600}$ X F.L. X 133% = 75% F.L. (approx) satisfying objective (1) for voltage drop.

$\frac{2000}{3600}$ X F.L. X 200% = 110% F.L. (approx) satisfying objective (2) for current carrying capacity for leads and fuses.

From a practical standpoint all these figures are translated into handy tables by Western Electric (see T-80909-12 for crossbar tandem).

In those cases where continuous current is required even though the circuit is not handling a call (filament current, motors, etc.), the List 2 figures will reflect this constant drain.

It is of course apparent that the foregoing procedure could be simplified considerably by eliminating the power plant calculation factors and simply specifying full load figures for List 2. These would then be used directly to obtain the desired engineering objectives. However, no steps were taken by the Labs in 1941 to change the engineering practices and the Labs now feel that these present practices are so firmly entrenched that any fundamental change would result in severe field reaction. In any case, the engineering results are still the same regardless of the method employed.

The "safety" factors employed to determine lead and fuse sizes and the associated voltage drop criteria are covered on standard power plant calculation drawings (as SD-80965-01 for 300 type plants). These factors call for List 2 figures to be modified as follows:

- For calculating lead sizes from a current carrying standpoint, a peak value equal to 133% of all variable loads should be used. For steady or constant loads, which are already at their peak, further adjustment is not required.
- For calculating fuse sizes from a current carrying standpoint, a value equal to 150% of the circuit peak drain is used, or 200% of the List 2 figure.

The so-called "circuit peak" for variable loads drain is equal to 133% of th List 2 value. This peak drain is the maximum current to be carried by the lead and takes into consideration periods of extremely heavy traffic as Mothers Day, Christmas or natural disasters.

For constant loads, the current drain values reflect peak demand and the 133% factor would not apply. In summary then, the current drain relations would be -

Circuit peak for variable loads, I_v = (List 2 drain) X 1.33

Circuit peak for constant loads, I_c = List 2 drain

Once the peak current requirements and voltage drop limitations are known, the minimum lead size required can be determined. It can be shown for any conductor that

$$R = \frac{\rho L}{A}$$

where R is the resistance of the conductor in ohms, L is the length of the conductor in feet, A is the cross-sectional area of the conductor in circular mils and ρ is the resistivity of the conductor material in ohm-circular mils per foot. Substituting

$$R = \frac{V}{I}$$

$$\frac{V}{I} = \frac{\rho L}{A} \quad \text{or} \quad A = \frac{I\rho L}{A}$$

In calculating the minimum lead size required, A, in circular mils

I = peak current, I_v or I_c

ρ = resistivity of copper, 11.1 ohms - circular mils per foot for wire (see <u>Power Data</u> book, section 16.22, sheet 2) or 10.3 for bus bar

L = length in feet of the conductor run

V = maximum voltage drop permitted

In calculating the required fuse size,

$$\text{fuse size} = (I_v \text{ or } I_c) \times 1.5$$

It can be seen that if the load is variable,

$$\begin{aligned}\text{fuse size} &= (\text{List 2 drain}) \times 1.33 \times 1.5 \\ &= (\text{List 2 drain}) \times 2.0\end{aligned}$$

As an example, assume that a variable - 48-volt load of 40 amps (List 2 load on a miscellaneous fuse bay fuse panel) will be fed from a single BDFB fuse. The installed power plant is a 300-type and the length of the cable run between the BDFB and the miscellaneous fuse bay is 100 feet. Consulting Table 4, SD-80965-01, the maximum permissable voltage drop between the BDFB and the fuse bay is 0.125 volt (Note that Table 4 lists the loop voltage drop for battery and ground return and therefore the 0.25 volt must be divided by 2. Some SD's will list the "one-way" voltage drop). The "peak" current drain may be calculated

$$\begin{aligned}I_v &= (\text{List 2 drain}) \times 1.33 \\ &= (40 \text{ amps}) \times 1.33 = 53.3 \text{ amps}\end{aligned}$$

The required lead size, A, is

$$A = \frac{\rho I_v L}{V}$$

$$= \frac{11.1 \frac{\text{ohms-cm}}{\text{ft.}} \times 53.3 \text{ amps} \times 100 \text{ ft.}}{0.125 \text{ volt}}$$

cancelling appropriate units $\left(1 \text{ ohm} = 1 \frac{\text{volt}}{\text{amp}}\right)$

$$A = 4.73 \times 10^5 = 473{,}000 \text{ circular mils}$$

In consulting the Power Data book, table A, section 16.22, sheet 2 (see figure 6.17), it can be seen that a single 500,000 lead would be required.

In selecting the BDFB fuse, the fuse size required would be

$$\begin{aligned}\text{minimum fuse size} &= I_v \times 1.5 \\ &= (53.3 \text{ amps}) \times 1.5 = 80 \text{ amps}\end{aligned}$$

A standard fuse having at least an 80-amp capacity would be selected. The rating of the fuse selected should never exceed the current carrying capacity of the fused lead (as shown in table A, section 16.22, sheet 2 of the Power Data book). In some cases, this may result in selection of a larger size lead than that required to satisfy current and voltage drop requirements.

A "Power Lead Calculator" (which can be ordered from Western Electric) can be used to make lead size determinations. As shown in figure 6.18, for a given cable length, current carrying requirement and voltage drop, the required cable size may be read directly from the calculator. As shown in figure 6.18,

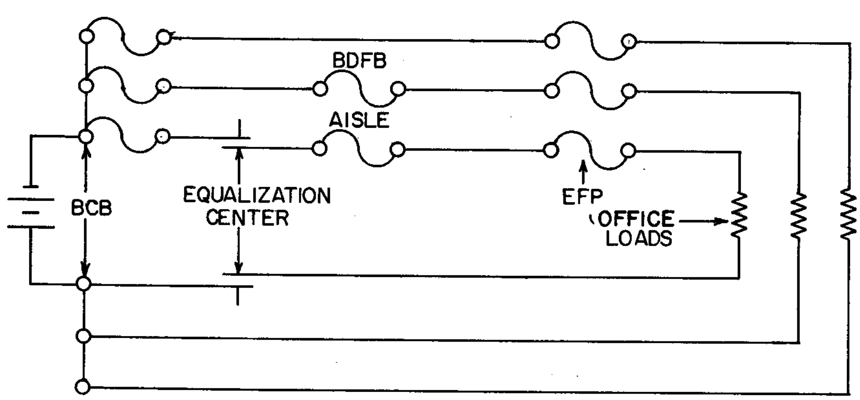
SIZE AWG NO.	AREA IN CM	CURRENT CARRYING CAPACITY SEE NOTES 3 & 4 AMPERES		DIA BARE COND INCHES	DC RESISTANCE 1000 FT AT 25C(77F) OHMS		60 CY REAC 1000 FT OHMS	RHW DIA OVER INS INCHES	RHW BEND. RADIUS INCHES	RHW NET WEIGHT PER 1000 FT POUNDS		RHW MAX SHIP. LENGTHS PER REEL IN FEET SEE NOTE 7	RHWL DIA OVER LEAD SHEATH INCHES	RHWL NET WEIGHT PER 1000 FT POUNDS
		COPPER			TINNED COPPER					COPPER				
14	4,110	15		0.064	2.68		0.056	0.19	0.95	26		5,000	0.25	115
12	6,530	20		0.081	1.68		0.051	0.21	1.05	35		3,000	[illegible]	128
10	10,380	30		0.102	1.06		0.051	0.24	1.20	49		3,000	0.32	260
8	16,510	45		0.146	0.679		0.044	0.31	1.55	84		3,000	0.38	320
6	26,250	65		0.184	0.427		0.045	0.40	2.00	126		2,000	0.47	520
4	41,740	85		0.232	0.269		0.045	0.45	2.25	190		1,500	0.52	620
2	66,370	115		0.292	0.169		0.039	0.51	2.55	278		1,000	0.58	770
1/0	105,500	150		0.373	0.106		0.037	0.63	3.15	443		1,000	0.68	[illegible]
2/0	133,100	175		0.418	0.0843		0.040	0.68	3.40	540		1,000	0.73	1,210
4/0	211,600	230		0.528	0.0525		0.035	0.78	3.90	814		1,000	0.84	1,570
	350,000	310		0.681	0.0320		0.036	0.98	4.90	1,310		750	1.06	2,470
	500,000	380		0.814	0.0222		0.034	1.12	5.60	1,815		500	1.19	3,160
	750,000	475		0.998	0.0148		0.034	1.34	6.70	2,700		360	1.45	4,620
						NONPREFERRED (RHH) (SEE NOTE 9)								
4/0	211,600	235		0.528	0.0525		0.035	0.78	3.90	814		1,000		
	750,000	500		0.998	0.0148		0.034	1.34	6.70	2,700		360		

Figure 6.17 - Table A, Section 16.22, Sheet 2, Power Data Book

using the values in our previous example, the calculator also indicates that a 500,000 cm lead is required.

All power supply circuits leading from the power plant to other parts of the central office are fused to protect the wiring and the power plant equipment. The carrying capacity of each fuse is limited to a value that will protect the wire connected to it against overheating in case of a short circuit or ground. Where a large lead supplies current to a number of smaller leads, each of the smaller leads is also calculated to handle the office and apparatus load. As stated earlier the fuse size is based on 150% of the circuit peak load.

Series fusing is encountered when intermediate distribution from power equalizers and BDFB's are fused and they, in turn, feed equipment fuse panels (EFP) as shown below:



Thus the battery reaches the office load via two and in some cases three power fuses.

It is desirable to have a large ratio between the primary and secondary fuses in order to reduce

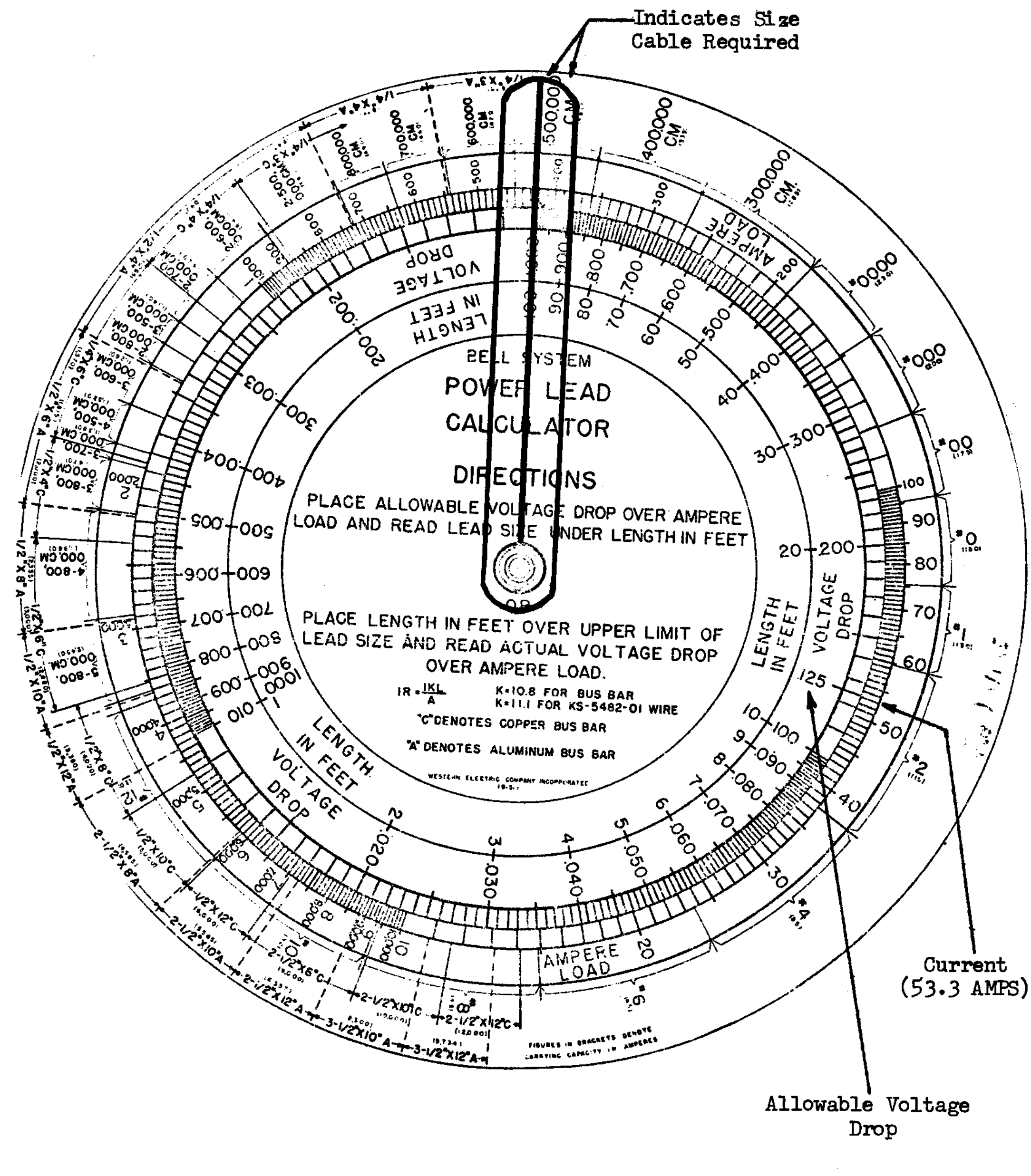


Figure 6.18 - Use of the Power Lead Calculator

the possibility of operating main fuses at the power board. Failure of the main fuse would of course open all branch circuits fed from this source. In toll systems, the main fuse should be sized to be the greater of (1) 400% of the largest secondary fuse it supplies or (2) 150% of the circuit peak load on the main lead. For dial or local systems, the main fuse should be sized to be the greater of (1) 250% of the largest secondary fuse it supplies or (2) 150% of the circuit peak load on the main lead. Again, the fuse rating should never exceed the maximum current carrying capacity of the lead it is designed to protect.

PART B - SECTION 7.0

BATTERIES, END CELLS AND COUNTERCELLS

7.1 Introduction

As covered in Part B, Section 6.0, charging equipment is used to convert AC power to DC to operate telephone equipment. Since commercial AC power is subject to failure, it is important that an alternate or emergency DC supply be provided in order to protect service. This is accomplished by one of two means: installing back-up emergency AC engines and batteries or installing only batteries. This section only covers the engineering of batteries. Part B, section 8.0 outlines requirements for engineering emergency engines.

Most DC power plants are equipped with some form of battery back-up which is provided for two reasons: (1) in the event of a commercial AC power failure which renders the charging equipment inoperative, the batteries supply power to the telephone equipment until the commercial AC power is restored or an emergency AC supply is activated; and (2) to act as a filter in reducing the noise induced in the DC output of the charging equipment.

In smaller offices, the cost of a stationary emergency AC supply is prohibitive and sufficient batteries are provided to maintain service until the commercial AC power can be restored or a portable emergency AC supply can be brought to the site. When no stationary emergency AC supply is installed, batteries are usually sized to provide at least 24 hours of continuous service before failing (normally referred to as a 24-hour reserve).

In larger offices, the cost of the batteries required to maintain a 24-hour reserve becomes prohibitive. Therefore, stationary emergency AC supplies are installed and only a three-hour battery reserve need be maintained to provide for starting the engine and transferring the load to it. In offices attended twenty-four hours a day, normally only a two-hour reserve is required. Under certain conditions (as during transition work), the two, three and twenty-four hour reserves can be further reduced with the concurrence of both Telephone Company Engineering and Plant representatives.

In engineering batteries for a typical telephone power plant, three approaches are usually available for consideration:

1. Provide an initially oversized battery string that doesn't require supplementary strings through the nominal life of the battery (8 or 15 years).
2. Provide a smaller battery of such size that a supplementary string will be required in six to eight years.
3. Provide a battery of such size that a supplementary string will be required within approximately two to three years.

The approach selected for engineering an initial installation or addition should be based upon economics and certain other factors:

1. For maintenance reasons, the ultimate number of battery strings associated with any one power plant should be kept to a minimum (generally limited to three or four strings if possible). Of course, if a three-hour reserve must be maintained and more than four strings are required, they must be provided.
2. If no stationary emergency AC supply is installed, when will one be provided and the battery reserve reduced to three hours?
3. The floor space presently available or projected to be available for battery strings.
4. Future plans to replace or relocate the power plant, or replace equipment being served by the plant.

The Telephone Company engineer is responsible for specifying both the size and number of strings to be provided in a power plant.

7.2 Types of Battery Plants

Batteries in telephone plants are normally "floated". The term "floated implies offsetting the load with an equal output of the charging equipment. This allows the batteries to float on the line, neither charging nor discharging. Because of internal losses, the batteries actually require a small amount of current. Thus, the battery string is maintained in a fully charged condition and is ready at all times to supply the load either during a failure of the AC equipment or during peak periods when the drain exceeds the plant charging capacity. Under present operating practices batteries are floated at 2.17 volts per cell (2.2 volts per cell for emergency cells). However, it should be noted that the open circuit voltage of a fully charged cell is about 2.00 volts. The additional 0.17 volt dissipates almost immediately after the cell is taken off float voltage. The expected life of the batteries, under float conditions, is from eight to fifteen years, depending upon the type of battery used.

Standard telephone power plants are designed to meet certain voltage requirements as specified in BSP 800-610-165. The basic factor which determines the operating voltage range of a power plant is the number of cells in the battery plant. Once the number of cells is selected, the plant float voltage is automatically determined (since it will be 2.17 volts per cell multiplied by the total number of cells).

There are two types of batteries used in present power plants. The lead antimony grid type (KS-5361, KS-5553 and KS-5562) can be used in any power plant. The lead calcium grid type, KS-15544 and KS-15886 (Md'd), should be used only in closely regulated power plants. Section 3, paragraph 2.7 of the AT&T Power Engineering Manual lists the advantages and disadvantages of each type. In general, all but the smallest type plant will use the KS-15544 type unless the KS-5562 floor type is required to provide the required battery reserve. Figures 7.1 - 7.3 show the three battery plant equipment configurations that are used in most telephone company power plants.

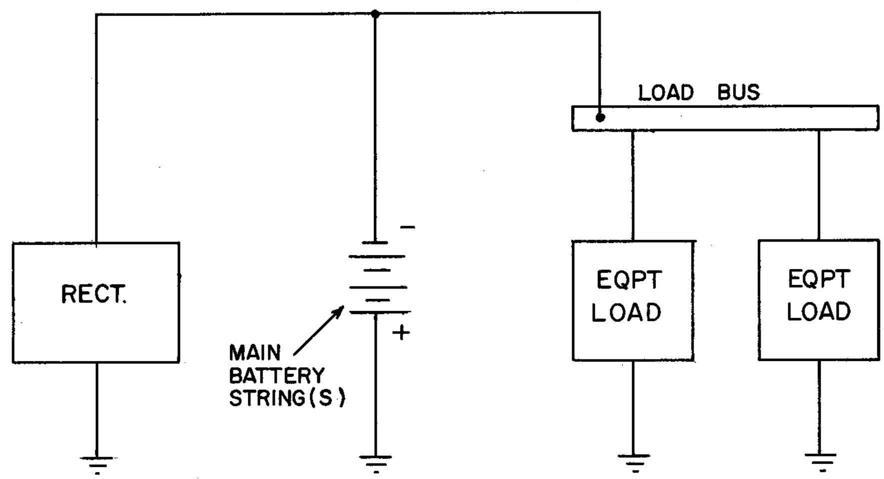


Figure 7.1 - Battery Only Plant

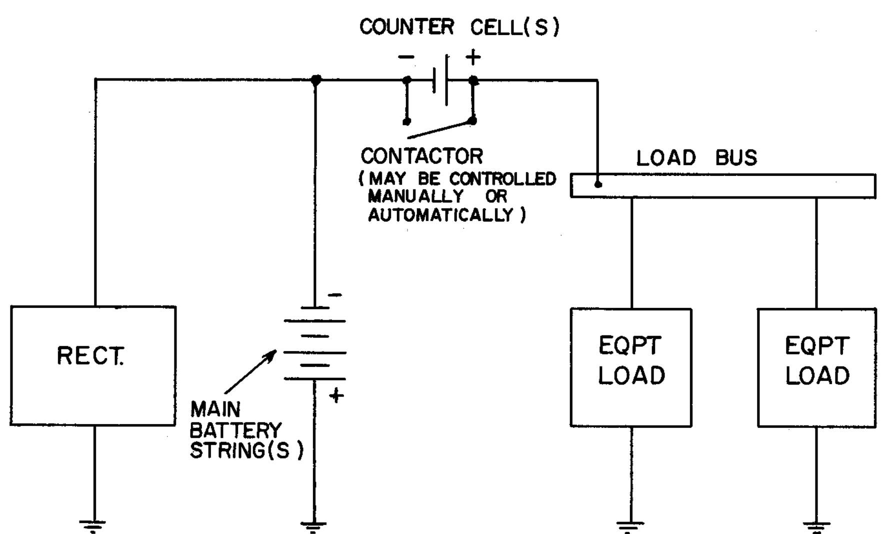


Figure 7.2 - Battery and Counter Cell Plant

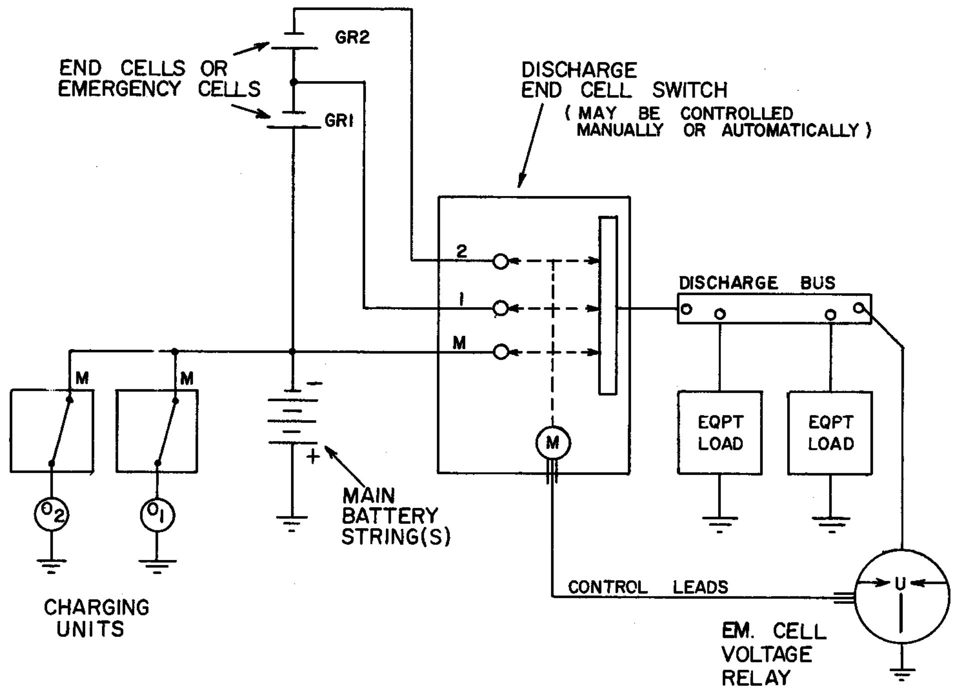


Figure 7.3 - Battery and End Cell Plant

The plant design in figure 7.1 uses neither end cells nor countercells. Upon rectifier failure, the float voltage of the batteries is all that is available to power the load. Once this voltage drops below a specified minimum, the equipment ceases to operate. Certain power plants are only available in this arrangement. Others permit optional use of either counter or end cells (see figures 7.2 and 7.3). Table A lists some of the more widely used plants and their operating methods.

POWER PLANTS PERMITTING		
No Counter or End Cells	Use of Counter Cells	Use of End Cells
326A	105E	302A, B
411A & B	110A	702C
413A	111A	
425A & B	410B	
413A		

Table A - End or Countercell Arrangements - Typical Plants

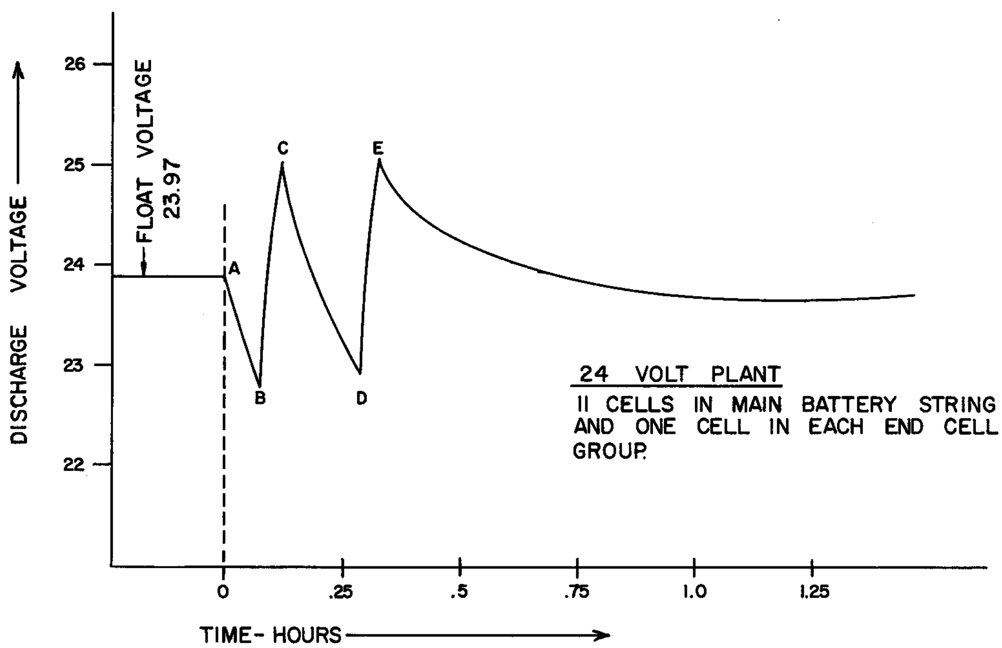
Certain power plants (figure 7.2) use counter cells to help prolong the necessary battery voltage during a power failure. These plants use more cells in the battery string than are necessary to maintain the normaloperating voltage of the equipment being served. The CEMF cell has no storage capacity and acts as a dropping resistor and decreases the voltage in the battery string by a nominal two volts per CEMF cell. They can usually be switched out of the circuit either manually or automatically. During a power failure the battery voltage starts to drop as the batteries discharge. The CEMF cells are switched out of the battery string, thus raising the effective voltage of the string by two volts for each CEMF cell switched out of the circuit. Some plants are provided with countercells to reduce the voltage for test purposes only. In these cases they are manually switched into the circuit during testing only.

As an example, some 100-type, 48-volt plants use twenty-four cells which are floated at 52.08 volts (24 X 2.17). A two-volt countercell can be connected in the circuit to reduce the voltage to about fifty volts at the equipment fuse panels. In a discharge condition, the countercell is shorted out by the countercell contactor. The twenty-four cells will then discharge to the minimum voltage the equipment can tolerate. The Telephone Company engineer is also responsible for sizing the countercells in this type of plant.

In power plants equipped with end cells (figure 7.3), load current is normally supplied by the charging units. If the charging units fail, load current is supplied by the main battery string. Load current is fed to the discharge bus through the M (BATT) contacts of the end cell switch. Assume the charging units in figure 7.3 have failed. The main battery supplies load current and begins discharging. When the discharge bus voltage decreases to a predetermined point, Group 1 end cells will be automatically placed in series with the main battery string. As discharge of the main battery string and Group 1 cells continues, the discharge bus voltage will again decrease to a predetermined lower limit. At this time the Group 2 end cells will be placed in series with the main battery string and the Group 1 end cells. Figure 7.4 shows how the discharge voltage is affected as the end cells are cut into operation. The Telephone Company engineer is also responsible for sizing the end cells in this type of plant.

7.3 Age Correction Factor

Engineering Letter (E.L.) 114 discusses in some detail the effect aging has on the capacity of a battery. The curves attached to this E.L., reproduced here as figure 7.5, show how the capacity of certain list 300,400 and 500 batteries decreases with age. As the curves show, the capacities of these batteries may fall below 100 percent of their rated capacity before the end of their nominal fifteen-year life. It is also apparent that the capacities of some decrease more rapidly than others, depending upon the type of battery and manufacturer. One of the conclusions drawn in the E.L. is that in sizing KS-15544 lead-calcium batteries for engineering purposes, it should be assumed that 75% of the rated capacity will be available at the end of the nominal fifteen-year life even though the curves indicate otherwise. E.L. 114 also points out that (1) the capacity of the smaller KS-15886 and 5361 batteries should be assumed to



Point A - Main battery string begins discharging.

Point B - End cell switch moves to position 1.

Point C - Group 1 end cells begin discharging.

Point D - End cell switch moves to position 2.

Point E - Group 2 end cells begin discharging.

Figure 7.4 - Power Failure Discharge of 24-Volt Power Plant Having End Cells

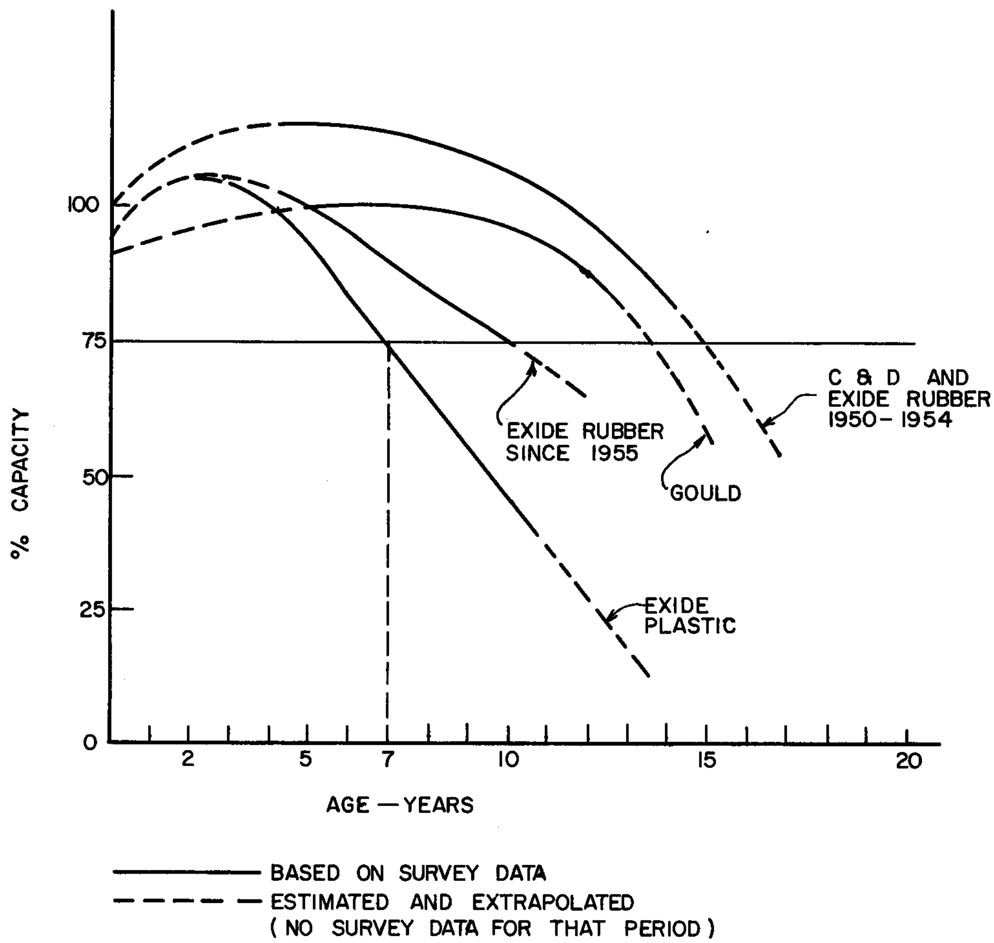


Figure 7.5 - Aging Characteristics of KS- 15544 Batteries

be 100% at the end of their nominal 8-year life and (2) the capacity of the KS-5562 and KS-5553 lead-antimony batteries should be assumed to be 75% of the rated capcaity at the end of the nominal 15-year life. The General Building and Equipment Engineer in his two letters dated 4-15-69 and 11-12-70 (File E-1B10.4) outlined methods for accounting for this reduction in capacity when sizing batteries or determining hours of reserve. A theoretical increase in load is assumed (referred to as the "drain corrected for age"[1]) which mathematically approximates this decrease in battery capacity. Figure 7.5 may be used to determine the rated capacity for list 300,400 or 500 battery strings of a given age if actual capacity information is not available.

The age and condition of the battery cells should be taken into account when establishing an assumed capacity figure for strings of KS-15886, 5361, 5553 and 5562 batteries.

BSP 157-601-701, section 3.11, outlines procedures for performing discharge capacity tests (additional information concerning list 300,400 and 500 cells is contained in the Southwestern addendum to BSP 157-601-504). When available, results of the discharge capacity tests should be used in establishing the capacity figure to be used in battery calculations for a particular string. As can be seen in table 2 of E.L. 114, a discharge capacity test sample indicates the general capacity range of the entire string. For battery calculations, a specific capacity figure must be established from this indicated range.

For example, let's assume that a discharge capacity test of four cells of a string (KS-15544) indicate the following capacities: Cell No. 1 (bottom shelf of stand) - 71.6%; Cell No. 7 (bottom shelf) - 73.0%; Cell No. 14 (top shelf) - 72.5%; Cell No. 16 (top shelf) - 69.2%. The average of this four-cell sample is 71.6%. Since there appears to be no major difference between the capacities of the cells on the top and bottom shelf, it probably can be assumed that the four-cell sample is representative of the string capacity. Therefore, a capacity figure of 72% can be used in completing battery calculations. If, on the other hand, the four-cell sample indicated the following: Cell No. 1 (bottom shelf) - 82.1%; Cell No. 7 (bottom shelf) - 85.3%; Cell No. 9 (bottom shelf) - 84.4%; Cell No. 16 (top shelf) - 63.8%, something other than the four-cell sample average (78.9%) should probably be used in completing the appropriate battery calculations. Assuming a two-tier stand with twelve cells on each shelf, the following averaging process may be more appropriate:

$$\frac{12\ (84\%) + 12\ (79\%)}{24} = 81.5\%$$

where 84% is the approximate average capacity of the cells on the bottom shelf and 79% is the assumed average capacity of the cells on the top shelf.

In most cases, when sizing new batteries, the manufacturer of the batteries to be furnished by Western Electric Company is unknown. It must be assumed that 75% or 100% (depending on the KS of the cell) capacity will be reached at the end of the nominal life unless KS-15544 cells are being installed (figure

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1 Line J of the "Power Plant Data Sheet" (see figure 7.11)

7.5 can be used in interpolating between the 100% and 75% points for KS-15544 cells).

Once the capacity figures have been determined for each string, table B can be used to determine the age-correction factor. For example, if the capacity of a string was estimated to be 80%, table B indicates that the age-corrected drain would be obtained by multiplying the actual drain by 1.20 (the age correction factor).

CAPACITY OF BATTERY, %	% INCREASE IN LOAD	AGE CORRECTION FACTOR
100	0	1.00
95	5	1.05
90	10	1.10
85	15	1.15
80	20	1.20
75	25	1.25

Table B - Age Correction Factor for Various Battery Capacities

Since many power plants have more than one string of batteries, applying the age correction factor to determine the reserve becomes more difficult, especially if the batteries are of different sizes or were installed at different times. Figure 7.6 shows the form to be used when computing the age correction factor for multiple string plants. An example of a completed form SW-5074 is shown in figure 7.12.

7.4 Battery String Sizing and Replacement

As stated in sections 7.1 and 7.2 the Telephone Company engineer is responsible for sizing the batteries and end cells in the various power plants. Each type of equipment has high and low emergency operating voltage limits. The term "final volts per cell" (FVPC) represents the lowest voltage per cell in a battery string that can be reached before equipment failures begin. BSP 800-610-165 lists the operating voltage limits for the various types of equipment. The voltage limits given in this BSP are at the equipment fuse panels and not at the battery terminals. The allowable voltage drop between the battery and the circuit fuses is usually shown on the discharge circuit for each power plant.

The first step in selecting the battery size is to determine the final volts per cell (FVPC) that can be tolerated. The FVPC is the minimum voltage that can be experienced across each cell in a battery string while still providing satisfactory operation of all equipment components served by that string. It is determined by dividing the sum of (1) the most critical (highest) low emergency voltage limit and (2) the voltage drop between the batteries and that equipment item by (3) the total number of cells that will be in the battery string after the countercells have been switched out or the end cells have been

OFFICE ____________
CITY ____________
SPEC NO ____________

BATTERY CAPACITY AGE CORRECTION CALCULATIONS FOR MULTIPLE STRINGS

DATE ____________
ESTIMATE REQUEST ____________

	______ VOLT PLANT / BATTERIES: YEAR INST/MAKE	STRING	LIST	(A) CAP A.H.	(B) PERCENT LOAD PER STRING (NOTE 1)	(C) AGE CORR. FACTOR PER STRING	(D) TOTAL AGE CORR. FACTOR (B X C)	(E) TOTAL DISCH DRAIN (NOTE 2)	(F) TOTAL DISCH DRAIN CORR FOR AGE (D X E)	(G) DISCH DRAIN PER STRING (B X F)	(H) HOURS RES PER STRING (NOTE 3)	
PRESENT 19__	From Power Engineering Manual					From Figure		X	X			FVPC ____
	or Power Data Book → (to A)					7.5 and		X	X			
						Table B		X	X			
								X	X			
								X	X			
TOTAL					X	X				X	X	
END OF POWER ENGR PERIOD 19__						Total Average Age Correction Factor For	(↑ to D)	X	X	From Battery Discharge	(↑ to H)	FVPC ____
						Power Plant Record on		X	X	Curves or Tables.		
						Line "I" of the Power		X	X			
						Plant Data Sheet.		X	X			
								X	X			
TOTAL					X	X				X	X	
ESTIMATED 19__								X	X			FVPC ____
								X	X			
								X	X			
								X	X			
								X	X			
TOTAL					X	X				X	X	

NOTES:

1. B = A(PER STRING) ÷ A(TOTAL)
2. RECORD FROM LINE "H" OF POWER PLANT DATA SHEET
3. IF ALL CALCULATIONS HAVE BEEN MADE CORRECTLY ALL STRINGS SHOULD HAVE THE SAME HOURS RESERVE, HOWEVER, DUE TO ROUNDING AND INTERPOLATION OF THE DISCHARGE CURVES AND TABLES THERE MAY BE A SLIGHT DIFFERENCE. USE THE AVERAGE TO RECORD ON LINE K OF THE POWER PLANT DATA SHEET.

Figure 7.6 - Battery Capacity Age Correction Calculations for Multiple Strings, Form SW- 5074

switched into the circuit:

$$\text{FVPC} = \frac{\text{Critical low emergency voltage limit + voltage drop (batteries to equip)}}{\text{Total number of battery cells}}$$

Minimum emergency voltage limits may be obtained in BSP 800-610-165. Voltage drop limitations between the batteries and the served equipment are normally reflected on the SD drawings for the discharge circuit. As outlined in the AT&T Power Engineering Manual, no final volts per cell above 1.90 or below 1.75 should be used in the selection of a battery plant. Below 1.75 volts/cell, performance of individual cells is erratic and considerable power is required to recharge the batteries (because of the inefficiency of the cells discharged below 1.75 volts/cell). Since the voltage per cell drops rapidly from 2.17 volts per cell when batteries are taken off of float voltage, no final volts per cell greater than 1.90 should be used. Section 1 of the AT&T Power Engineering Manual shows several examples of calculating the minimum allowable FVPC.

The second step is to pick a battery string(s) that will provide adequate reserve at the projected discharge load assuming an appropriate FVPC. As discussed in part B, section 7.1, sufficient battery reserve is usually provided to permit operation of the office for a minimum of three or twenty-four hours. A three-hour reserve is usually maintained in locations equipped with stationary emergency engines and a 24-hour reserve in all others. However, with the agreement of the appropriate Plant representatives, either a shorter or longer reserve may be maintained. For instance, if a location is attended twenty-four hours a day, the time needed to start the emergency engine and transfer the loads to the emergency bus is reduced and only a two-hour reserve need be maintained. An office's reserve may also be temporarily reduced during power transition work. This should be covered with the appropriate Plant representatives at some time prior to the start of the job.

In some cases, it may be appropriate to provide more than twenty-four hours of reserve. For instance, an office not equipped with an emergency engine and located in a remote area subject to frequent AC power failures may be engineered for more than a twenty-four hour reserve because of the extreme difficulty in reaching the site.

When provided, the three-hour reserve should be sufficient to carry the office for three hours at the busy hour (busy season) load. The 24-hour reserve should be sufficient to care for the projected busy season 24-hour drain.

Section 3 of the AT&T Power Engineering Manual contains tables that show the discharge capacities of the standard available batteries at the various FVPC. This information is also reflected in graph form in section 5 of the Power Data book. Both of these sections also list the physical and electrical characteristics of the available batteries.

When engineering for a 24-hour battery reserve, the variable and constant components of the busy hour drain must be identified (see part B, section 4.2). In addition, the power failure drain must also be determined (see part B, section 4.6). If the drain for a particular plant is comprised of both variable and constant loads, a graph of this drain for a 24-hour period might look like that shown in figure 7.7. If the total area under the curve (ampere-hours) could be determined, it would reflect the battery capacity needed to carry the office for twenty-four hours. Since this area is not easily determined, it can be approximated using the following method:

1. Determine the BH peak drain for the variable load and convert it to an equivalent 24-hour drain. In this conversion process, assume the BH drain will be experienced for eight hours.
2. Determine the constant drain.
3. Determine the power failure drain.
4. Total 24-hour drain = 1+2+3.

Steps 2 and 3 are rather straight forward and are discussed in part B, sections 4.2 and 4.6. The equivalent 24-hour variable drain (step 1) may be determined in the following manner:

A. Calculate the variable drain by subtracting the constant drain from the BH peak. In our example shown in figure 7.7, this is 50 amps (BH peak) - 10 amps (Constant) = 40 amps (variable).

B. Convert this 40 amps of variable drain to an equivalent 24-hour drain using the table shown in figure 7.8 for the appropriate final volts per cell (assume 1.90 for this example).

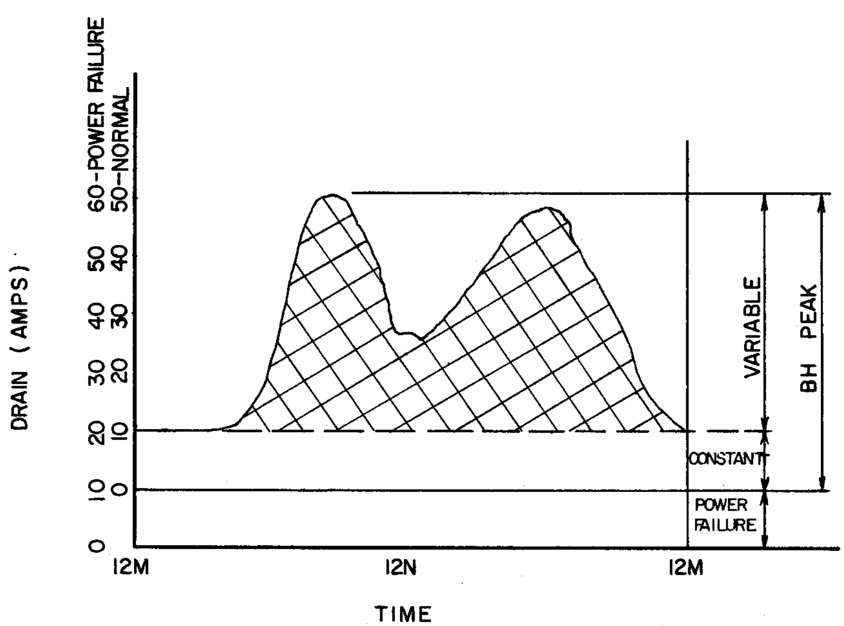
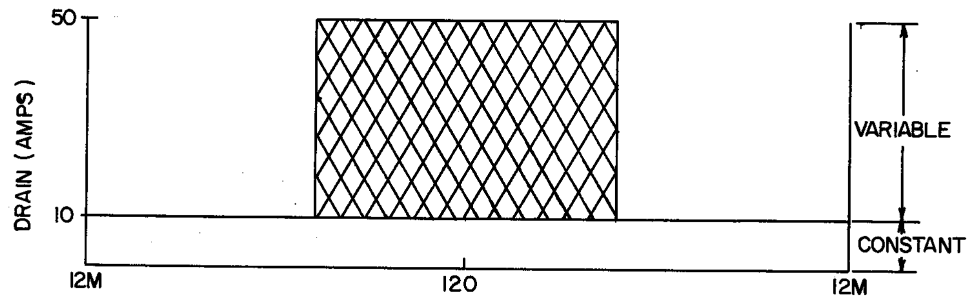


Figure 7.7 - Typical 24-Hour Battery Drain

In making this conversion, it is first assumed that the variable drain is an 8-hour drain and could be represented graphically as follows:



The cross-hatched area above represents the total ampere-hour discharge of the variable drain and closely approximates the area of the cross-hatched section in figure 7.7. However, as can be seen in figure 7.7, the variable drain discharge occurs over a 24 rather than an 8-hour period. Initially, mathematically averaging the variable drain over the 24-hour period (40 amps ÷ 3 in our example) might appear to be an acceptable method for recognizing that the drain actually occurs over a 24-hour period. However, a mathematical averaging process fails to account for the non-linear discharge characteristics of the batteries. For example, referring to the discharge curves in figure 7.10, it would require 6 hours for a list 409 cell to discharge to 1.75 volts if the imposed load were 100 amps. Assuming linear discharge characteristics, a load of 50 amps (one-half the load) would require 12 hours (twice the time) to discharge to the same 1.75 volts. However, it can be seen in figure 7.10 that the 50-amp load actually requires 15 hours to discharge the cell to 1.75 volts.

The equivalent 24-hour variable load can be derived through a somewhat tedious procedure using the appropriate battery discharge curves. However, the table shown in figure 7.8 can be used in making this conversion. As the note at the bottom of figure 7.8 indicates, the equivalent 24-hour variable drain is simply the assumed 8-hour drain divided by the conversion factor.

In our example, the conversion factor for the 40-amp variable load would be 2.22 (assuming 1.90 FVPC). Therefore, the 24-hour equivalent variable load would be 40-amps ÷ 2.22 or 18 amps. The total 24-hour battery drain may then be calculated to be 18 amps (24-hour equivalent) + 10 amps (constant) + 10 amps (assumed power failure) = 38 amps.

The battery size required to maintain a 24-hour reserve could be determined by entering the battery discharge curves at 38 amps (assuming an age correction factor of 1.0) and proceeding horizontally to the right until the 24-hour reserve line is intersected (point ①). In this case (see figure 7.9), the two lines intersect at the L-501 curve. If the two lines intersect between two discharge curves, the larger batteries should usually be selected since installation of the smaller batteries will result in a reserve of less than 24 hours.

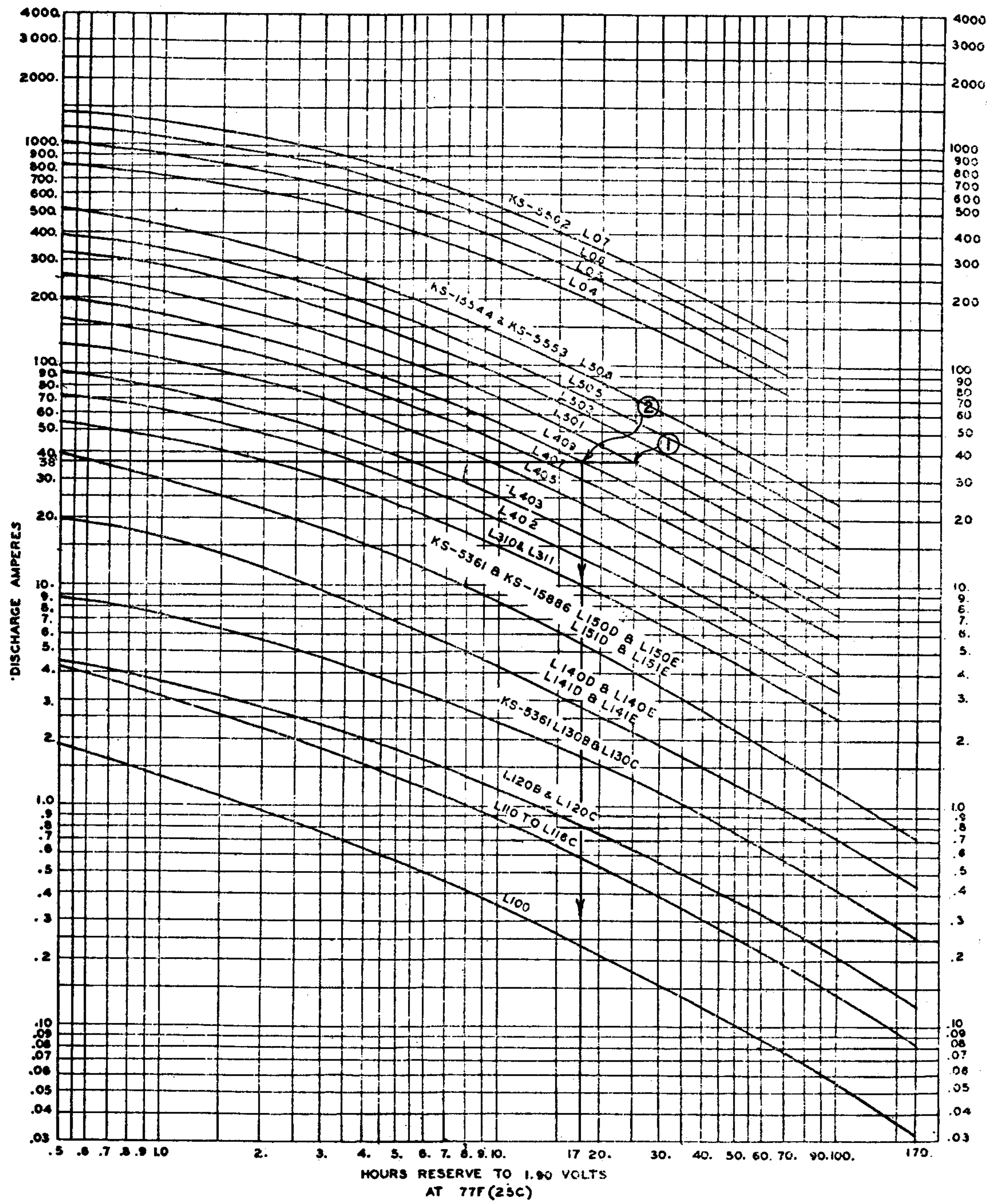
The process for checking the hours of reserve provided by an existing battery string is similar.

Discharge Final Volts per Cell	8-Hour Variable Drain, Amps	Conversion Factor (see note 1)
1.75	0-4.0	2.17
	4.1-7.0	2.33
	7.1-15.0	2.50
	15.1-25.0	2.44
	25.1-750.0	2.35
	750.1-	2.20
1.78, 1.79, 1.80	0-4.0	2.10
	4.1-7.0	2.30
	7.1-13.0	2.40
	13.1-24.0	2.34
	24.1-55.0	2.18
	55.1-300.0	2.27
	300.1-600.0	2.14
	600.1-800.0	2.25
	800.1-	2.11
1.83, 1.84	0-4.0	2.26
	4.1-8.0	2.32
	8.1-15.0	2.55
	15.1-30.0	2.12
	30.1-150.0	2.25
	150.1-300.0	2.17
	300.1-	2.10
1.86	0-4.0	2.13
	4.1-8.0	2.33
	8.1-15.0	2.44
	15.1-30.0	2.15
	30.1-250.0	2.20
	250.1-700.0	2.13
	700.1-	2.10
1.88	0-3.0	2.01
	3.1-7.0	2.25
	7.1-13.0	2.38
	13.1-40.0	2.14
	40.1-200.0	2.17
	200.1-	2.08
1.90	0-3.0	1.96
	3.1-5.0	2.18
	5.1-10.0	2.28
	10.1-40.0	2.22
	40.1-150.0	2.17
	150.1-300.0	2.20
	300.1-	2.02

Note 1 - 24-hour equivalent variable drain = 8-hour variable drain ÷ conversion factor

Figure 7.8 - 24-Hour Equivalent Variable Drain Conversion Factor

POWER DATA SECT: 5:15 SHEET: 10
AT&T CO. STANDARD



BATTERY DISCHARGE CURVES
TO 1.90 VOLTS PER CELL

Figure 7.9 - Typical Use of Battery Discharge Curves in Calculating a 24-Hour Reserve

The discharge curves should be entered at the appropriate 24-hour battery discharge drain and followed horizontally until the discharge curve for the installed battery is intersected. The hours of reserve associated with that drain may be determined by reading down vertically to the horizontal axis. In the example of figure 7.9, assume that the power plant is equipped with one battery string of KS-15544 L-409 cells. To determine the battery reserve, enter the discharge curves at 38 amps and proceed horizontally until the L-409 curve is intersected (point (2)). In reading down vertically, it can be determined that this one string provides a 17-hour reserve, which indicates an additional battery string is needed (to meet the 24-hour reserve requirement).

For power plants having only a constant drain, there is no variable component and the 24-hour battery drain consists only of the constant drain plus the power failure drain. Assume in figure 7.7 that the variable drain did not exist; the 24-hour drain would be 20 amps, 10 amps (constant) + 10 amps (power failure). The process for determining the appropriate battery list number or hours reserve would be the same as above, except that 20 amps, rather than 38 amps, would be used in making the determinations.

In making determinations for power plants requiring only a 3-hour battery reserve, it must be assumed that the failure will occur during the office busy hour. Therefore, the total battery drain consists of the BH peak drain plus the power failure drain or, for constant drain plants, the constant drain plus the power failure drain. As an example, assume that the total battery drain corrected for age is calculated to be 350 amps and the FVPC required is 1.75. To determine the appropriate size battery to carry the load for 3 hours, use the battery discharge curves for 1.75 volts per cell (see figure 7.10) to find the intersection of the 350-amp drain and 3-hour reserve line (point (1)). As seen in figure 7.10, these two lines intersect at a point between the discharge curves for the L-505 and L-508 batteries. The 350-amp drain line intersects the L-505 curve at approximately 2.6 hours and L-508 at approximately 4 hours. Therefore, in order to meet the minimum 3-hour reserve requirement, L-508 cells must be provided.

To determine the hours reserve provided by an existing battery string, enter the discharge curves with the 3-hour battery drain and proceed horizontally until the discharge curve for the existing battery is intersected. Then read down vertically to determine the hours reserve. For example assume the 3-hour total drain corrected for age is 500 amperes for a power plant with one string of L-508 batteries requiring a FVPC of 1.75. Enter the discharge curves at 500 amps and go horizontally until the L-508 curve (point (2) in figure 7.10) is intersected. Reading down vertically it can be determined that the string of L-508 cells provides a 2.2-hour reserve. This would indicate that an additional battery string is needed to meet the 3-hour minimum requirement.

In some cases multiple battery strings must be provided in order to meet the reserve requirement. In others, the choice may exist between one large string or two or more smaller strings. Use of the battery discharge curves has been discussed previously and, for the sake of clarity, all the examples were based upon use of only one battery string. In those cases where more than one battery string is installed

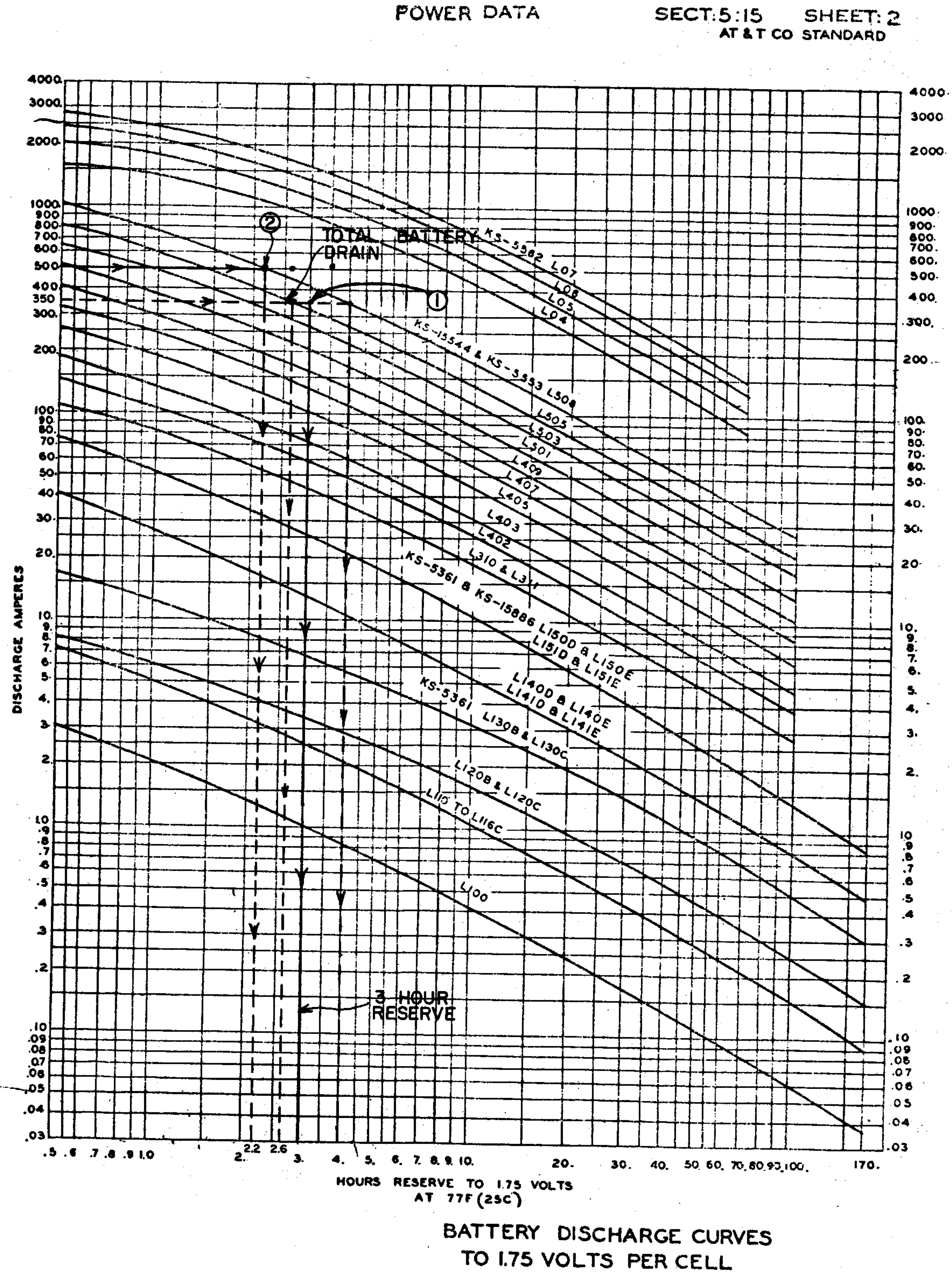


Figure 7.10 - Typical Use of Battery Discharge Curves in Calculating a 3-Hour Reserve

or being considered for installation, it is first necessary to determine what portion of the load each battery string will assume during a discharge condition. The following formula may be used to calculate the number of amperes which will be handled by any one battery string during a discharge condition:

$$\text{Amperes} = \frac{\text{Ampere-hour rating of one battery string}}{\text{Total ampere-hour rating of all strings in parallel}} \times \text{total discharge amperes (corrected for age)}$$

Once this has been determined for each string, the hours of reserve can be determined or verified. The discharge curves are used in the same manner as that shown in previous examples, except that only the drain associated with each string is used in making the determination. If calculated properly, the hours of reserve provided by each string in a multi-string plant should be the same, since each string assumes a portion of the load in direct proportion to its stated capacity.

For example, assume a power plant has a battery discharge drain corrected for age of 600 amps and is presently equipped with one string of KS-15544 L-508 cells and 1 string of KS-15544 L-505 cells. The office is equipped with a 303A power plant and discharge to 1.75 FVPC is permissable. The AT&T Power Engineering Manual shows capacity of the L-508 to be 1680 ampere-hours (A.H.) and the L-505 to be 1320 A.H. The discharge load the L-508 will carry is then determined as follows:

$$\text{Load } 508 = \frac{1680}{1680 + 1320} \times 600 = 336 \text{ amps}$$

The L-505 will then carry the difference, or 264 amps. The discharge curves for 1.75 FVPC show that for 336 amps a L-508 string has approximately 4¼ hours reserve and that at 264 amps a string of L-505's has the same reserve.

Sizing new batteries for a multi-string plant is not always straight forward and may require a trial and error process. For example, if a 3-hour reserve was required at 1.75 FVPC for a 600-amp load, the discharge curves will show that this falls between the L-508 and L-04 curves. The choice then lies between one L-04 or two or more smaller strings. The curves show that the load could be carried using 2 strings of L-508, or 3 strings of L-501, or 6 strings of L-407, or perhaps a combination of these. In making this selection, it may be desirable to use the economic study techniques outlined in part B, section 2.2. In general, it will be found that, economically, the KS-5562, tank-type cells cannot be justified except in the larger 300- or 700-type plants, where the number of KS-15544 L-508 strings required to meet the reserve would be great.

For maintenance and cost reasons, the objective should be to keep the number of strings to a minimum. For a new plant it usually will be found best to engineer all battery strings to be the same type and size. It is usually only as a plant grows that mixing of battery types and sizes will be required or justified.

All of the examples used in the sizing of batteries or determining the reserve have used the battery discharge curves from the Power Data book. These curves were constructed from information shown in the battery discharge ampere capacity tables in section 3 of the AT&T Power Engineering Manual. These tables can be used in lieu of the curves for most battery calculations and can be read with considerably more accuracy.

The "Power Plant Data Sheet", form SW-5073, is used to record and summarize battery reserve calculations, power plant data and emergency engine data (see figure 7.11). This form is included in the Vice President-Engineering's and Chief Engineer's copies of the estimate request if money for power plant equipment is included in the estimate request. When the age correction factor is not the same for all strings shown on the "Power Plant Data Sheet", the "Age Correction Factor Calculation Sheet", form SW-5074, should also be included in appropriate copies of the estimate request along with the "Power Data Sheet" (see figure 7.12). If no power equipment is being added, a "Power Plant Data Sheet" or an updated copy of the SWX-XXXX-550-G drawing should still be completed and included in the Chief Engineer's copy of the estimate request.

As discussed in section B, part 7.3, the capacity of a string of batteries decreases with age. The typical curves shown in figure 7.5 reflect only statistical averages of this aging process. The capacities of individual strings may deteriorate at much slower or faster rates than those shown in these curves. Since the capacity of the string will eventually deteriorate to the point that the string should be replaced, the capacities must be monitored at periodic intervals.

BSP's 157-601-501 thru 505 (including Southwestern addendums) outline requirements for completing these capacity tests. In some cases, an addendum specifies when the initial and subsequent capacity tests should be made and detail the criteria to be used in evaluating the results of those tests. If the capacity tests indicate a string should be replaced, the appropriate Plant organization should forward to the Engineering department a copy of the test results, a Central Office Equipment Recommendation and an Engineering Complaint if appropriate. An Engineering Complaint may be processed if the string has not lasted as long as its anticipated life (as outlined in Table B, BSP 157-601-701). Submission and successful action on an Engineering Complaint results in credit being issued by Western Electric for the unused portion of the battery life. In deciding whether or not the Engineering Complaint should be processed, the Equipment Maintenance Engineer's organization must decide if the prospective credit allowance justifies the costs associated with processing the complaint. Justification for replacing a battery string because of suspected deteriorated capacity must be based on capacity tests rather than on the age of the battery in comparison to its anticipated life.

At times, the condition of individual cells in a string may justify replacement of the affected cells (see BSP 157-601-703 for typical examples of defective cells). If three or fewer cells are involved, Plant personnel may choose to replace the cells on a maintenance basis. Otherwise, the Engineering department should be sent a C.O.E.R. outlining the condition of the cells and requesting replacement of the string. When replacing individual cells in a battery string, the Bell Laboratories recommends that the replacing cells be of the same manufacturer as the other cells in the string. Both the float (see BSP

OFFICE XYZ
CITY Big Town
SPEC NO 4A30.29

POWER PLANT DATA SHEET

DATE 3-10-72
ESTIMATE REQUEST 10000

		______ VOLT PLANT	NOTE	PRESENT 19 72	END OF PWR ENGR. PERIOD 19 75	ESTIMATED 19 82
PER PLANT		TYPE OF PLANT		111A	111A	303A
		PLANT CAPACITY (AMPS)	1	400	400	2000
		TOTAL EQUIPPED CHARGING CAPACITY (AMPS)		300	400	1200
		CHARGING CAPACITY, LARGEST UNIT (AMPS)		100	100	400
BATTERY RESERVE CALCULATIONS - PER PLANT	A	FINAL VOLTS PER CELL		1.90	1.90	1.75
	B	BATTERY STRINGS - QUANTITY/LIST (YEAR INST)		1/505(1960	1/505(1960 1/508(1973	1/508(1973 1/508(1980
	C	BUSY HOUR PEAK DRAIN (AMPS)		180	260	600
	D	VARIABLE DRAIN (AMPS)		160	200	400
	E	VARIABLE DRAIN — 24 HOUR EQUIV. (AMPS)		-	-	-
	F	CONSTANT DRAIN (AMPS)		20	60	200
	G	POWER FAILURE DRAIN-ADDITIONAL (AMPS)		15	15	25
	H	TOTAL BATTERY DISCHARGE DRAIN (AMPS)	2	195	275	625
	I	AGE CORRECTION FACTOR - ALL STRINGS		1.25	1.11	1.13
	J	TOTAL DRAIN CORRECTED FOR AGE (AMPS)		245	305	705
	K	BATTERY RESERVE PROVIDED (HRS)		2.5	7.2	4
	L	BATTERY RESERVE REQUIRED (HRS)		3	3	3
PER PLANT		MAXIMUM DEMAND (KW) - THIS PLANT	3	13.5	19.5	45
PER OFFICE		MAXIMUM DEMAND (KW) - TOTAL OFFICE		20	27	55
		ENGINE-ALTERNATOR CAPACITY (KW)		30	30	75

NOTES: 1 SHOW TOTAL CHARGE CAPACITY RATING OF THE POWER PLANT
2. FOR 3 HOUR RESERVE – B + D + E
FOR 24 HOUR RESERVE – C + D + E
3. KW RATING FOR BH PEAK DRAIN

Figure 7.11 - Power Plant Data Sheet, Form SW-5073

OFFICE XYZ
CITY Big Town
SPEC NO 4A30.29

BATTERY CAPACITY AGE CORRECTION CALCULATIONS FOR MULTIPLE STRINGS

DATE 8-10-72
ESTIMATE REQUEST 10000

	____ VOLT PLANT BATTERIES YEAR INST/MAKE	STRING	LIST	(A) CAP A.H.	(B) PERCENT LOAD PER STRING (NOTE 1)	(C) AGE CORR. FACTOR PER STRING	(D) TOTAL AGE CORR. FACTOR (B X C)	(E) TOTAL DISCH DRAIN (NOTE 2)	(F) TOTAL DISCH DRAIN CORR FOR AGE (D X E)	(G) DISCH DRAIN PER STRING (B X F)	(H) HOURS RES PER STRING (NOTE 3)	
PRESENT 19 72	1960/Exide	A	505	1320	1.00	1.25	1.25			245	2.5	FVPC 1.90
	TOTAL			1320			1.25	195	245			
END OF POWER ENGR PERIOD 19 75	1960/Exide	A	505	1320	.44	1.25	.55			134	7.2	FVPC 1.90
	1973/ -	B	508	1680	.56	1.00	.56			171	7.2	
	TOTAL			3000			1.11	275	305			
ESTIMATED 19 82	1973/ -	A	508	1680	.50	1.25	.63			353	4	FVPC 1.75
	1980/ -	B	508	1680	.50	1.00	.50			353	4	
	TOTAL			3360			1.13	625	705			

NOTES:

1. B=A(PER STRING) ÷ A(TOTAL)
2. RECORD FROM LINE "H" OF POWER PLANT DATA SHEET
3. IF ALL CALCULATIONS HAVE BEEN MADE CORRECTLY ALL STRINGS SHOULD HAVE THE SAME HOURS RESERVE, HOWEVER, DUE TO ROUNDING AND INTERPOLATION OF THE DISCHARGE CURVES AND TABLES THERE MAY BE A SLIGHT DIFFERENCE. USE THE AVERAGE TO RECORD ON LINE K OF THE POWER PLANT DATA SHEET.

157-601-701, par. 3.02(a)3) and aging characteristics of the various manufacturer's batteries vary and every effort should be made to avoid mixing cells of different manufacturers in the same string.

The equipment engineer requesting authorization for replacement of a battery string is responsible for determining that the criteria for replacement are being met (in many cases this determination may have already been made by the Equipment Maintenance Engineer's organization).

Occasionally, battery strings being removed from an office may be available for reuse at another location. A capacity test should be conducted (if not completed recently) and a determination made as to the adequacy of the string for reuse before it is shipped to its new location. Arrangements must be made to ship the cells filled with electrolyte and, upon receipt at the new location, a second capacity test should be conducted to insure that the cells were not damaged during shipment.

7.5 Countercell Sizing and Replacement

As outlined in section 7.2, countercells are used to decrease the plant discharge voltage by approximately 2 volts per countercell. In some power plants they are normally in the discharge circuit and are switched out only during power failures. In others, they are only switched into the circuit to obtain the proper test voltage level or to reduce the discharge voltage during the time a battery boost charge is being applied. The number of countercells required to drop the voltage depends upon the code (as 111A) and voltage of the power plant. Since the countercells are in the discharge circuit, they must be able to handle the maximum discharge (plant) capacity of the associated plant. If more than one is used in series, as required in some plants, then each one must be sized to the maximum discharge capacity. In some cases, the discharge capacity may be greater than the capacity of any available single countercell. The capacity may then be provided by paralleling two or more countercells. It is the responsibility of the Telephone Company engineer to size the initial countercells and to replace existing ones if the drain data indicates the load will exceed the rated capacity of the countercells. When engineering in an office equipped with a countercell, the countercell's capacity should always be checked against the discharge drain.

There are three types of countercells found in most power plants: (1) wet, (2) dry and (3) resistor. The wet-type provided per KS-5170 is no longer used in new plants but may be found in some existing plants. They require considerable maintenance, and present some explosion and fire hazards. The wet-type cell should be replaced with the dry-type when either unusual maintenance conditions exist or a change in capacity is required. In addition, wet-type cells should be replaced in all unattended offices on a next-job basis, and, because of the extreme difficulty in adding to and replacing the CEMF solution, may be considered for replacement in an attended office if it is located on the top shelf of a three-tier rack.

There are two major types of dry-type (semiconductor) countercells presently in use: the selenium KS-15928 and silicon KS-20637. Both of these offer substantial advantages over the wet-type since they require very little maintenance and do not present a fire or explosion hazard. Using the selenium cell, which was the first dry-type cell available for use, there is a possibility that a heavy load short circuit might open-circuit the cell before the circuit fuse operates. Therefore, plants utilizing the selenium cell under load conditions must be modified to prevent a service interruption (see AT&T Power Engineering Manual, section 3, paragraph 3.15). The newer silicon cells fail short-circuit, thereby eliminating the possibility of a service interruption. All new plants equipped for countercell operation are designed to use dry-type countercells, with the silicon-type being specified wherever possible. The drawings of some of the power plants are being changed to reflect use of the silicon rather than the selenium cell, depending upon the size and type of the plant.

Load resistors were used in some of the constant-drain, small-capacity, older power plants. The voltage drop across the resistors is directly related to the size of the discharge current; therefore, this arrangement usually provides a means for strapping out part of the resistance when the discharge current is below the maximum rated capacity of the resistor. This allows the voltage drop to be adjusted to approximately the desired value. A number of these plants now have provisions for replacing the resistor with dry-type countercells. This usually is done only when unusual maintenance conditions exist or a change in capacity is required. The discharge circuit of the power plants list the codes of the resistors that are used as countercells. The Power Data book, section 5, gives complete descriptions and capacities of most of the wet- and dry-type countercells. This information also indicates that the voltage drop for all wet-and dry-type countercells varies somewhat with their operating temperature and the load being handled. Except in abnormal situations, these output variations can be ignored. Section 14 of the Power Data book provides the same information for dropping resistors.

To illustrate the steps required in sizing CEMF cells, three examples will be considered. First, assume that a new -48 volt, 111A power plant with a discharge capacity of 400 amps is being engineered. The projected BH load is 120 amps and the plant is equipped initially with three 100-amp rectifiers. The countercell should be sized for the maximum plant discharge capacity, which in this case is 400 amps. One KS-20637, L2 silicon dry cell, rated at 400 amps, should be specified for use in this plant.

As a second example, assume the wet-type countercells in a 24-volt, 110A power plant are being replaced. The plant is equipped with a discharge capacity of 120 amps and four 30-amp rectifiers to handle the projected 80-amp BH load. Since the plant is equipped with two series-connected countercells (for a 4-volt drop), each one should be sized for the 120-amp plant discharge capacity. Two KS-20637, L-1 silicon dry cells, rated at 120 amps each, should be specified.

Finally, assume a growth job is being engineered in an office and the capacity of the countercell must be checked. The office is equipped with a -48 volt, 110A power plant, with a discharge capacity of 120 amps. The present BH load is 60 amps with a projected BH load of 85 amps. There are three 30-amp rectifiers in the plant and the installed countercell is a KS-5170, L-150. The Power Data book indicates the capacity of the KS-5170, L-150 is 75 amps. This wet-type countercell should be replaced on the growth job with a 120-amp capacity dry-type cell per KS-20637, L-1.

Some power plants that use countercells may be arranged for more than one discharge circuit or load. Each of these discharge circuits must be equipped with separate countercells that match the maximum discharge capacities of the individual discharge loads. The 110A power plant, as an example, can be expanded to a maximum discharge capacity of 640 amps: two 120-amp discharge loads and one 400-amp load. One 120-amp countercell should be provided in each of the 120-amp discharge circuits and one 400-amp countercell in the 400-amp discharge circuit. When separate discharge loads are provided, the capacity of the individual discharge circuits should not be exceeded. It is, of course, quite possible to exceed the capacity of one of the discharge circuits while still being well below plant capacity when all loads are considered. Care must be taken to insure that the load is balanced among separate loads (when provided) to eliminate the possibility of a severe service interruption.

Some of the smaller power plants may use a different type of dry countercell than those previously discussed. The individual plant discharge circuits will provide information concerning the type to be used. For example, the 410B, 130-volt, 66-cell plant was originally equipped with either 25-amp or 40-amp load resistors. The discharge circuit indicates the resistors can be replaced with a J86864C-1, 40-amp CEMF unit which provides a dry-type, KS-20019 countercell. In this case, engineering information is provided in the power plant BSP, the discharge circuit SD, and equipment J drawing rather than in the Power Data book.

7.6 Battery Stands

Some of the small power plants provide a tray on the plant control and/or rectifier bays for mounting the batteries and countercells. All others, except the KS-5562 floor-mounted battery cell, will require a separate battery stand. The 802-000-000 BSP index lists some of the BSP's that are available to help in the selection of battery stand equipment. The individual power plant battery equipment BSP's will also usually reference the associated battery stand equipment. In order to avoid a building addition (and only as a last resort), a battery string can be split between two stands if adequate floor space is not available to include all the cells on one stand.

Selection of a battery stand and its location usually depends on one or more of the following:

1. Available floor space
2. Accessibility for maintenance
3. Future planned building additions
4. Future power plant growth plans
5. Busbar and cable arrangements or restrictions
6. Distance from power plant

7. Floor loading

If a new office is well planned, provisions are usually made for the orderly growth of all power plant equipment, including the battery stands. In these instances, the floor plans should show the intended locations for the optimum number of battery stands the plant will require. In many cases (especially in older offices), the floor paln layout will not indicate location of future battery strings and the preceding criteria must be used in selecting and locating the battery stands. The Floor Plan Data book provides some of the minimum dimensions that should be maintained between the sides of a battery rack and the adjacent equipment. Additional information is provided in section 7 of the AT&T Power Engineering Manual.

One of the most important of the previously mentioned seven items is the provision of adequate accessibility for maintenance purposes. The stand should, if at all possible, be placed where both sides are exposed and can be reached during maintenance activities. When one side of a two-row stand is placed against the wall, the inside row of battery cells is difficult to maintain and presents a safety hazard to Plant personnel. In addition, replacement of individual cells is made much more difficult. Locating a battery stand against a wall should be done only as a last resort and preferably only when a single-row stand is used. The 3T-1R stand is presently rated non-standard and will only be provided on a job (piece part) basis at the Telephone Company engineer's request. The 3T-2R stand is still standard for some 130-volt applications but its use should be avoided because of the difficulty in accessing all cells for maintenance personnel.

The bus-bar and cabling arrangements are also of prime importance, and may at times be the controlling factor in floor plan layout and stand selection. The battery stand arrangement should be layed out to minimize the amount of busbar or cable required for not only the length of the run but also because of voltage drop considerations.

Usually the Western Electric Company engineer will select new battery stands to meet the requirements of the batteries selected by the Telephone Company engineer. The stands will usually be located as specified by the Telephone Company engineer on the floor plan drawings. The Western Electric engineer is also responsible for selecting the proper intercell, interrow and intertier connectors. In those instances where the Telephone Company engineer details the job, he is responsible for ordering these items. New intercell, interrow and intertier connectors should usually be ordered when a complete battery string is being replaced.

7.7 Battery, Countercell and End Cell Entries, SWX-XXXX-550-G Drawing

The information outlined in this section may be used to record certain data in sections III A, B and C of the SWX-XXXX-550-G drawing as follows (see figure 7.13):

Practice Section	550-G Drawing Entry
B, 7.3	IIIA, Lines 7 & 8
B, 7.4	IIIA, Lines 3, 9, 10 & 11
B, 7.4	IIIB & IIIC
B, 7.5	IIIC

Section IIIC will list any end cells or countercells associated with the power plant. If end cells are used, this section will contain an entry for each battery string, since end cells are furnished on a per string basis (see figure 7.13). If countercells are used, this section will contain an entry for the countercells in each discharge circuit (see figure 7.13). The capacities for countercells should be shown in parenthesis under the "Type" column.

Sections IIIB and IIIC are designed to reflect end of engineering period quantities. When a string(s) or cells are being replaced, duplicate entries may be made to reflect both old and new quantities until the new equipment is installed. For batteries, the "Manufacturer" column should reflect the type battery case (plastic or rubber) installed.

A. BATTERY RESERVE CALCULATIONS

		PRESENT	PWR. ENGR. PER
1.	B.H. DRAIN – AMPS	160	220
2.	VARIABLE DRAIN – AMPS	108	133
3.	VARIABLE DRAIN – 24 HOUR EQUIVALENT - AMPS	—	—
4.	CONSTANT DRAIN – AMPS	52	87
5.	POWER FAILURE ADDITIONAL DRAIN – AMPS	76	76
6.	TOTAL BATTERY DISCHARGE DRAIN-AMPS (NOTE 1)	236	306
7.	AGE CORRECTION FACTOR – ALL STRINGS (NOTE 2)	1.0	1.04
8.	TOTAL DRAIN CORRECTED FOR AGE – AMPS (7 X 8)	236	318
9.	BATTERY RESERVE PROVIDED - HOURS	2.7	7.0
10.	BATTERY RESERVE REQUIRED - HOURS	3.0	3.0
11.	FV PC	1.90	1.90

NOTES: 1 FOR 3 HOUR RESERVE = LINES 2 + 4 + 5 ; FOR 24 HOUR RESERVE = LINES 3 + 4 + 5
2 AGE CORRECTION FACTOR PER STRING: PRESENT A (1.0)
PWR. ENGR. PER A(1.10), B(1.0)

B. BATTERIES, END OF POWER ENGINEERING PERIOD

STRING	TYPE (KS #)	LIST #	# CELLS	DATE INST.	SPEC	MANUF	CAP. TEST CAP.	CAP. TEST DATE
A	KS-15554	505	24	10-68	4431.72	EXIDE (PLASTIC)		
B	KS-15554	508	24	9-73	4431.104	EXIDE (PLASTIC)		
C								
D								
E								
F								
G								
H								

C COUNTERCELLS / ~~END CELLS~~, END OF POWER ENGINEERING PERIOD

STRING OR LOAD	TYPE (KS #) OR CODE	LIST #	# CELLS	DATE INST	SPEC	MANUFACTURER 1
A	KS-20637 (120 A)	1	1	9-73	4431.104	—
B	(120A)	1	1			—
C	(400A)	2	1			—
D						
E						
F						
G						
H						

NOTE: 1 ONLY REQUIRED FOR END CELLS

Figure 7.13 - Battery, Countercell and End Cell Entries, SWX-XXXX-550-G Drawing

PART B - SECTION 8.0
EMERGENCY PLANTS

8.1 Introduction

Maintaining telephone service, even under the most severe conditions, is a basic policy of the Bell System. Although most locations have a dependable source of commercial AC power, provisions must be made for operating the telephone plant should a commercial power failure occur. As discussed in previous sections, commercial AC power is in most cases converted to DC for operating telephone equipment. Batteries are provided for operating the equipment should the AC power fail. In larger offices, the cost of providing sufficient batteries to maintain the necessary reserve becomes prohibitive. In these offices, a backup AC supply is furnished, thereby reducing the requirement for backup batteries.

Figure 8.1 is a typical arrangement of an emergency AC supply system.

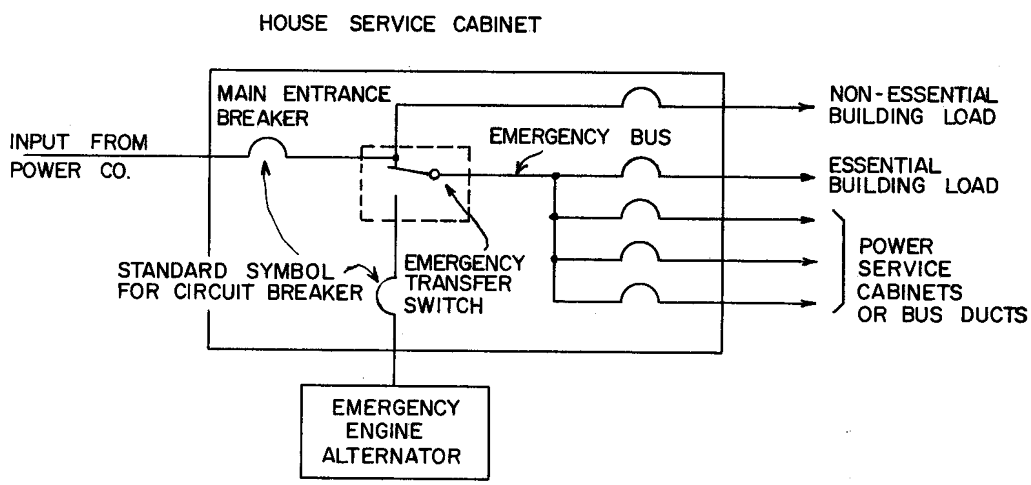


Figure 8.1 - Typical Emergency AC Supply System

The emergency AC supply or engine-alternator may either be permanently installed in the office or portable. If a portable engine is used, adequate hook-up facilities must be provided. The emergency transfer switch is used to transfer the telephone equipment and essential building load to the emergency engine-alternator after it has been started (the telephone equipment operates on batteries until the transfer switch is operated). Options are available for either manual or automatic start of the engine and manual or automatic operation of the transfer switch. In smaller offices, all building equipment may be capable of being supplied AC power from the engine-alternator. In this case, all non-essential building items would be turned off when the engine is run in order to avoid overloading the emergency engine.

Details regarding an office's emergency transfer switch arrangement is contained on the Architectural group's electrical details drawing for that office. Information about permanently installed (called stationary) engines are included on standard Western Electric T-drawings. Commercial AC power is not available at some remotely located telephone equipment buildings. In this situation, both primary and standby stationary AC supply equipment must be provided.

8.2 Types of AC Engine-Generator Supplies

Installed AC supply equipment may consist of either a gasoline, diesel or turbine engine and an AC generator. The size and type selected for use in an office will depend upon the office load characteristics.

A complete list of standard and manufacture discontinued engine generators or alternators is contained in a publication distributed by the General Architectural group in St. Louis. This publication lists all standard (ordered per J spec.) engines, their capacities, operating characteristics and sources for more detailed information. The list is updated and distributed to all Building and Equipment Engineers as new information becomes available. The latest copy can be found in the engineering library under file subject 1A2.08 or 1B10.07. This list serves as an update of information contained in BSP 802-001-150. Other engine-alternator systems are provided on a non-standard (or custom designed) basis, but they are limited primarily to portable engine applications.

8.3 Load Data

In order to determine (1) if an office requires an emergency engine, (2) if an existing emergency engine is adequate or (3) what size engine should be used, an accurate estimate must be made of the load to be placed on the engine.

As discussed in section 5.0, an emergency AC supply must be adequate to handle the telephone equipment and essential building loads during a commercial power failure. Included in these loads are:

- All telephone equipment, both AC and DC operated (including inverter plants and AC-operated ringing machines)
- Emergency lighting
- Compressor-dehydrator equipment
- One elevator in large, multi-story buildings
- Ventilating equipment
- Sump pumps
- Air conditioning equipment if the equipment is temperature-critical and ventilating fans are not adequate
- Antenna deicers, navigation lights at repeater or radio stations

Included in the essential building load are those items which must remain operative to insure the safety of either the building or its occupants or to maintain service. Non-essential building loads are normally not tied to the emergency bus and usually are not arranged for transfer to the emergency AC supply.

In order to determine either present, end-of-power-engineering-period or future (as 10 year) load requirements, the total telephone equipment drains must be determined and converted to KW requirements (the capacity of emergency engine-alternators are expressed in kilowatts or KW). The essential building load must then be determined and added to the telephone equipment load, resulting in the total KW demand to be placed on the emergency engine-alternator in the event of a power failure. Form SW-5075 shown in figure 8.2 will facilitate this determination and should be included with all estimates recommending changes in the emergency engine-alternator arrangement (see part C).

The form shown in figure 8.2 provides for recording of the following information:

All items - load and drain (as appropriate) data is recorded for the present (month and year), end of power engineering period (month and year) and estimated date (year only).

Telephone equipment load - both the amp drain and associated KW load will be recorded for each of the power plants in the office. If an inverter plant is served from the emergency AC bus, enter the AC input KW. If upon power failure the inverter plant is transferred to a DC input source, enter the KW for the DC input. If an AC ringing machine is transferred to DC upon power failure, enter the KW associated with the DC input. The "other telephone equipment" line should be used to record the KW load for miscellaneous equipment served from power service cabinets fed from the emergency bus during a commercial power failure. This information may be taken from the AC load table shown on the AC wiring list for the office. If this load table has not yet been compiled by Western Electric engineering, (1) the load (amps) for each item may be measured and the KW load calculated; or (2) the estimated load may be determined by calculating (from the SD's, Power Data book, etc.) the amps and KW load for each item fused at the power service cabinet.

Essential building load - amp and KW loads will be recorded for the emergency lighting. Only KW loads will be recorded for all other essential building loads.

Total load - summation of telephone equipment and essential building KW requirements.

Size of installed engine or engines - capacity, in KW, of the installed stationary emergency engine-alternators.

In larger offices, this form may have to be expanded to record additional power plants and/or emergency engine-alternators if the loads are split.

In order to illustrate the techniques required for completing form SW-5075, assume the following for the Matard 238 office:

1. The following peak BH drain requirements were determined using techniques outlined in section 4.0:

	Present 9-72	End of Power Engr. Period 9-75	Estimated 1982
-48V plant, amps	160	220	350
-24V plant, amps	45	50	65
+130V plant, amps	20	25	40
-130V plant, amps	15	20	30

Emergency Power Data Sheet

Office: ________________

E.R. ________________

	Present	End of Power Engr. Period	Estimated
	______	______	______
Telephone Equipment Load			
__________ Plant, KW (AMPS)	______	______	______
__________ Plant, KW (AMPS)	______	______	______
__________ Plant, KW (AMPS)	______	______	______
__________ Plant, KW (AMPS)	______	______	______
Inverter Plants	______	______	______
AC-Operated Ringing Machine	______	______	______
Other Telephone Equipment Load, KW	______	______	______
Essential Building Load			
Emergency Lighting, KW (AMPS)	______	______	______
Sump Pump, KW	______	______	______
Ventilating and Exhaust Fans, KW	______	______	______
Elevator, KW	______	______	______
Compressor-dehydrator, KW	______	______	______
Other (list), KW	______	______	______
______________	______	______	______
______________	______	______	______
	======	======	======
Total Load, KW	______	______	______
Size of Installed Engine(s), KW	______	______	______

Figure 8.2 - Emergency Power Data Sheet, Form SW-5075

2. Emergency lighting drain on the 48-volt plant is 10 amps. There are no inverter plants in the office and the ringing machine is DC-operated. Sump pump, compressor-dehydrator, and ventilating fan requirements are 2.5, 0.4 and 5.6 KW respectively. There are no elevators installed in the building and no building addition is planned until after 1982. A 30 KW engine is presently installed. The job covered by E.R. 11038 will be installed in September, 1973 and will exhaust in September, 1975.

The first step in completing the emergency power data sheet requires conversion of the amp drain figures to KW demand figures. Table G, section 4 of the AT&T Power Engineering Manual provides the tables necessary for this conversion. The entries and conversions for the Matard 238 office example are shown in figure 8.3.

Next, the KW demand of the essential building items must be determined and entered. Emergency lighting drain data may be obtained from the SD drawing covering the emergency lighting system (as SD-80713-01). Conversion to KW demand should again be made using Table G of the AT&T Power Engineering Manual. Since no building additions are planned during the study period, it has been assumed that no additional emergency lighting fixtures would be required. Were a building addition contemplated, an estimate would have to be made of the number of fixtures to be added and the additional KW demand would be calculated. The KW requirements for the sump pump and ventilating equipment (and any other essential building item not specifically discussed) can be determined from either the Architect's records or physical check by the Plant department. If a motor is involved and the horsepower can be determined, conversion to KW can be made using Table L, section 9 of the AT&T Power Engineering Manual. If the KS number of the compressor-dehydrator is known, the size of the compressor motor can be obtained from the appropriate 161 series BSP. A horsepower to KW conversion can be made using Table L, section 9 of the AT&T Power Engineering Manual.

Based on the load determinations, it was decided to replace the 30 KW with a 60 KW engine-alternator. The next section (8.4) will deal with engine size selection.

8.4 Determining Engine Requirements

A review of a central office's power requirements is usually made in conjunction with addition of telephone equipment. Although power study sheets are only included in estimates adding power equipment, they should be prepared for all major jobs (see part C). Included in this study is an estimate of the total KW demand for the office.

Each telephone equipment building is either equipped with a stationary engine or is arranged for connection of a portable engine. At some point in time, it becomes more economical to provide a stationary engine and maintain a three-hour reserve rather than maintain sufficient batteries for a twenty-four hour reserve (and provide connections for a portable engine). The following items should be considered when deciding whether to provide a stationary or portable engine:

Emergency Power Data Sheet

Office: Matard 238

E.R. 11038

	Present	End of Power Engr. Period	Estimated
	9-72	9-75	1982
Telephone Equipment Load			
-48V Plant, KW (AMPS)	12.0(160)	16.5(220)	26.1(350)
-24V Plant, KW (AMPS)	1.7(45)	1.9(50)	2.4(65)
+130V Plant, KW (AMPS)	4.0(20)	5.0(25)	8.0(40)
-130V Plant, KW (AMPS)	3.0(15)	4.0(20)	6.0(30)
Inverter Plants	0	0	0
AC-Operated Ringing Machine	0	0	0
Other Telephone Equipment Load, KW	0	0	0
Essential Building Load			
Emergency Lighting, KW (AMPS)	0.8(10)	0.8(10)	0.8(10)
Sump Pump, KW	2.5	2.5	2.5
Ventilating and Exhaust Fans, KW	5.6	5.6	5.6
Elevator, KW	-	-	-
Compressor-dehydrator, KW	0.4	0.4	0.4
Other (list), KW			
Total Load, KW	30.0	36.7	51.8
Size of Installed Engine(s), KW	30	60	60

Figure 8.3 - Example - Completed Emergency Power Data Sheet, Form SW-5075

- Number and cost (including timing) of battery strings for a 24- versus 3-hour reserve.
- Available floor space for both batteries and the proposed stationary engine.
- The projected KW demand for the building. Generally, floor space limitations and battery costs will dictate when a stationary engine is added in a building. However, the KW demand of the building must be less than the output of the portable engine available for use at the site. Otherwise, a stationary engine must be provided.
- Nature of load, accessibility of location and availability of commercial AC power.

When an engine-alternator is already installed in an office, the projected KW requirements for the end of power engineering period must be checked against the capacity of the engine. If the engine is adequate to handle the projected load, no action need be taken.

If an initial installation of an engine is warranted or if an existing engine is not adequate to handle the projected load, the new engine-alternator arrangement should usually be sized to handle requirements for an 8 to 10-year period. Depending upon floor space availability, an existing engine may either be replaced with a larger engine or left in place and paralleled with one or more new (same or different size) engines. In some cases, floor space considerations may warrant provision of a larger or smaller engine than that required to handle the 8 to 10-year projected load. The AT&T Power Engineering Manual (section 5, p. 5.3) states that the minimum load placed on an engine should not be less than 30% of its full KW machine rating.

In sizing engines for use at higher elevations, the altitude of the engine-alternator installation affects the available output. Details are furnished in tables in the appropriate 802-9XX-XXX BSP.

8.5 Other Engineering Considerations

Once the size of the engine-alternator necessary to handle projected requirements has been determined, certain other engineering decisions must be made. These items and the responsibility for these decisions are summarized in figure 8.4.

8.6 Floor Plan Considerations

The location of an emergency engine-alternator is usually determined at the time a new building or addition is planned. In most locations, the engine-alternator set is located in the basement of the building because of (1) the weight of the engine, (2) fuel tank access requirements and (3) air handling considerations. The relatively lightweight gas turbine sets may be located on the roof of a building provided the structure is adequate to handle the weight of the engine. In some of the major multi-story buildings, gas turbine sets are located on intermediate floors. In many locations no basements have been provided and no floor space is available in the building requiring a stationary engine. In that case, the engine set may be located in a separate building.

The Telephone Company architectural and equipment engineers are responsible for selecting the

Item	Responsibility			See Part B Section
	Arch. Engr.	Tel. Co. Equip. Engr.	W.E. Engr.	
1. Floor plan layout	X	X		8.6
2. Output voltage		X		8.7
3. Automatic vs. manual start		X		8.8
4. Selection of engine start equipment		X	X	8.9
5. Sizing exhaust ventilation and air intake systems	X	X	X	8.10, 8.11
6. Radiator location	X	X		8.12
7. Fuel storage system	X	X	X	8.13
8. Modifying 60 KW engine for 100 KW operation		X		8.14
9. House service termination	X	X		8.15

Figure 8.4 - Other Engineering Considerations for Emergency Engine-Alternator Systems

location of any emergency engines installed in the office. The floor space selected must, of course, be adequate to handle the emergency engine and its associated equipment (see figure 8.5). Where possible, the engine should be located against a non-growth wall to avoid relocation when a building addition is required. Consideration should also be given to the availability of intake air (both ventilation and combustion) and the accessibility of the exhaust flue or stack. Building codes now require that all engines be enclosed in a fire wall because of the potential fire hazard associated with the fuel.

8.7 <u>Output Voltage Requriements</u>

The Telephone Company equipment engineer is responsible for specifying the output voltage required for a given engine set. Many of the standard sets are available in more than one output voltage. The output voltage of the engine should usually be selected to match the voltage available at the house service cabinet from the commercial power source. However, in some large office applications an economic study may be required to compare the costs of (1) higher output voltage, step-down transformers (near the house service cabinet) and smaller cables or bus with (2) lower output voltage, no transformers and larger cables or bus.

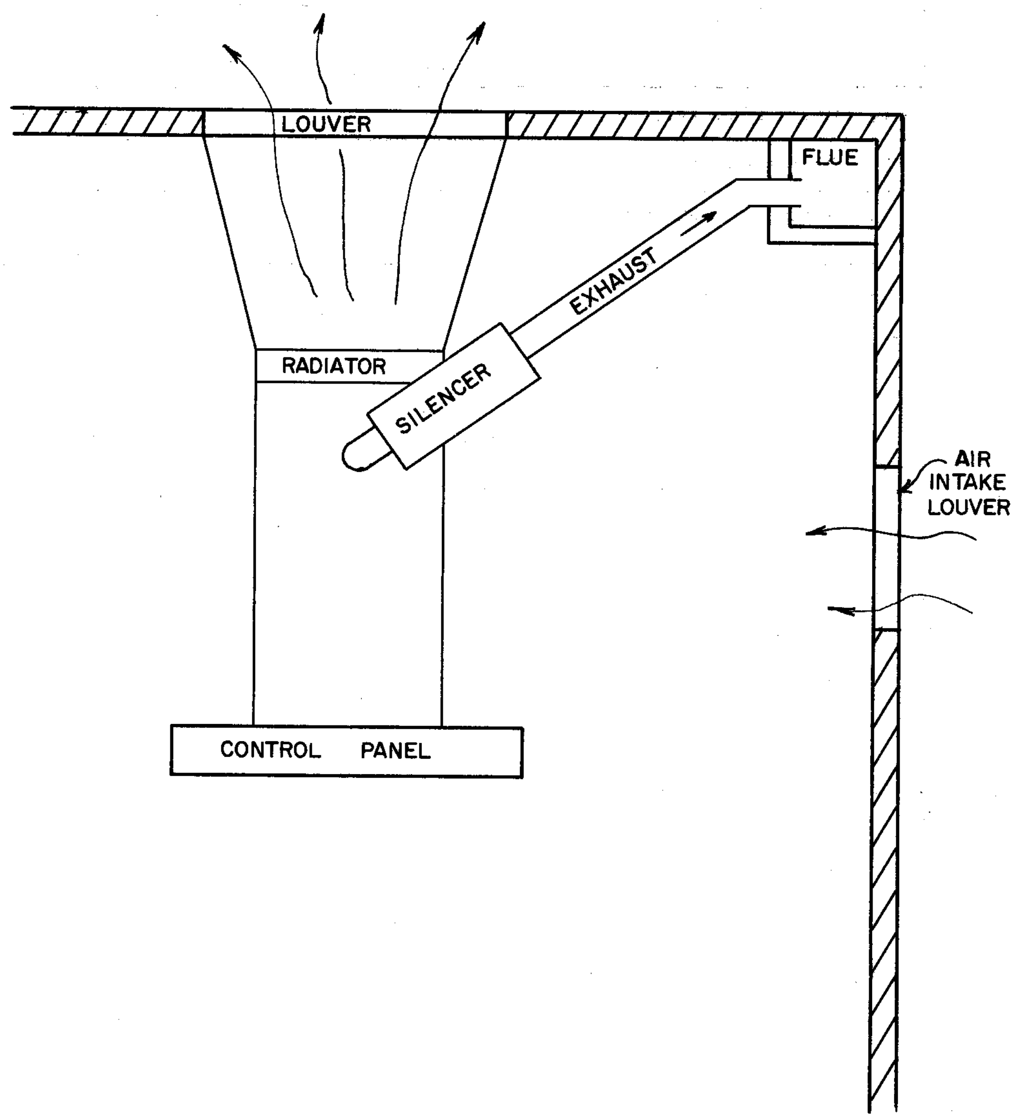


Figure 8.5 - Typical Diesel Emergency Engine-Alternator Layout

8.8 Manual or Automatic Controls

All sizes of standard diesel engines are available in either manual or automatic start arrangements. The Telephone Company equipment engineer is responsible for specifying the arrangement to be used. If automatic start features are required, automatic load transfer features should also be provided; i.e., there would be no reason to automatically start the engine if the load had to be transferred on a manual basis. The automatic transfer feature provides for load transfer after a specified engine warm up period.

Presently a few large central offices and repeater stations have been equipped with automatic start and transfer features. Most microwave or radio stations have also been equipped. Considerations for provision of automatic features are outlined in the AT&T Power Engineering Manual, section 5. Normally automatic features should not be provided unless unusual circumstances require doing so.

8.9 Engine Start Equipment

Almost all diesel engine-alternator sets are arranged for electric start via a dedicated string of engine start batteries (most newer installations use nickel-cadmium start batteries). Some of the larger diesel engines utilize compressed air for starting (this feature is still optional on the 500 KW diesel). All the gas turbine engine sets are electric start, although the larger sets employ an auxiliary gas turbine for starting.

If a choice is available, the Telephone Company equipment engineer is responsible for specifying the start method (battery or compressed air) to be employed. The batteries and trickle chargers (used to keep the start batteries fully charged) are provided as part of the J specification for the engine set. In order to insure start reliability, separate strings of start batteries should be provided for each engine installed in an office. The Telephone Company equipment engineer should also inform the architectural engineer of the AC input requirements for the trickle chargers (if required) in order that the correctly sized AC outlets may be provided.

8.10 Intake, Ventilation and Exhaust Systems - Diesel Engine

As shown in figure 8.5, the intake air system for a diesel engine must be capable of providing sufficient air for both combustion and ventilation. The architectural engineer provides the mechanical consulting engineer with the combustion and ventilating air requirements. The consulting engineer is responsible for design of the intake air louvers and associated equipment. Detailed intake and ventilating requirements are outlined in the 802-9XX-XXX BSP for the engine. Generally, capacities of diesel sets are not affected by intake or room temperatures unless they are being operated at altitudes at least 4,000 feet above sea level. In diesel installations, the oversize fans on the engine are usually large enough to cool the radiator and remove the heat generated by the engine, the silencer and the exhaust pipe. If the fan is not sufficient to handle all engine room heat, auxiliary fans must be provided by the consulting engineer. The size of the auxiliary fans can be determined using criteria in BSP 802-010-150. In order to minimize requirements for auxiliary fans, all silencers and exhaust piping should be insulated. Where remote radiators are installed, auxiliary fans or ventilating equipment will almost always be required since the radiator fan would not be available for removing heat dissipated by the engine. Diesel engine exhaust systems are designed by the Western Electric engineer using criteria outlined in BSP 802-006-150. The Western engineer is given the dimension of the Telephone Company pipe exhausting to the flue or stack of given dimensions (size determined by the architectural engineer). If the flue or stack openings are not sufficient, he advises the Telephone Company equipment engineer of the size required. After completion of detailed engineering, the Telephone Company is now being provided a detailed layout of the proposed exhaust system for their approval.

8.11 Intake, Ventilation and Exhaust Systems - Gas Turbine Engine

Intake air requirements become more critical in gas turbine installations because output power decreases as inlet combustion air temperature increases. Therefore, combustion air should be supplied from the coolest source possible, usually the outside air, via combustion air intake ducts. Typical intake and exhaust arrangements are shown in figure 8.6. The Western Electric engineer is responsible for sizing and providing the air intake duct. The architectural engineer specifies and provides the size and type opening in the wall for this duct (via the floor plan drawings or specs). The Western engineer notifies the Telephone Company equipment engineer if the size of the wall opening is not adequate. Two exhaust ducts are provided for larger gas turbine engines: the jet fuel starter and engine exhausts. For starting, the larger engines employ a small electrically-started auxiliary gas turbine called the jet fuel starter. A separate exhaust duct must be provided for the starter. The regular engine exhaust handles discharges from the engine air cooling system in addition to the engine exhaust. The engine compartment of the set enclosure is cooled by air drawn from the engine room and ejected into the engine exhaust duct. For the smaller engines, only the engine exhaust duct is required. Provision of both these ducts, including silencers, is the responsibility of the Western Electric engineer.

The alternator is also cooled by air drawn from the engine room through screened openings in the top of the set enclosure. In larger engines the heated air is discharged from the top of the enclosure and is usually ducted outside the engine room. Again, the Western Electric engineer is responsible for provision of this duct. In smaller installations, the heat generated by the alternator and engine is removed by the building ventilating system. If a radiator oil cooler is provided for mounting outside the building, location of the oil cooler must be specified by the Telephone Company equipment engineer.

The consulting mechanical engineer is responsible for provision of supplementary engine room ventilation equipment where required.

Detailed requirements for air intake, oil cooler, exhaust and ventilating equipment are outlined in the 802-980-XXX BSP for a specific engine. Flues and exhaust stacks are sized by the architectural engineer and are usually located against a column on the non-growing end of the building in order to minimize floor space made unavailable for equipment. The consulting mechanical engineer is responsible for design of all louvers and filters associated with openings for intake and exhaust gases. The louvers and filters are provided by the contractor as part of the building estimate and job.

8.12 Remote Radiator Considerations

Gas turbines employ air for cooling the engine. Diesel engines are water cooled and three cool-

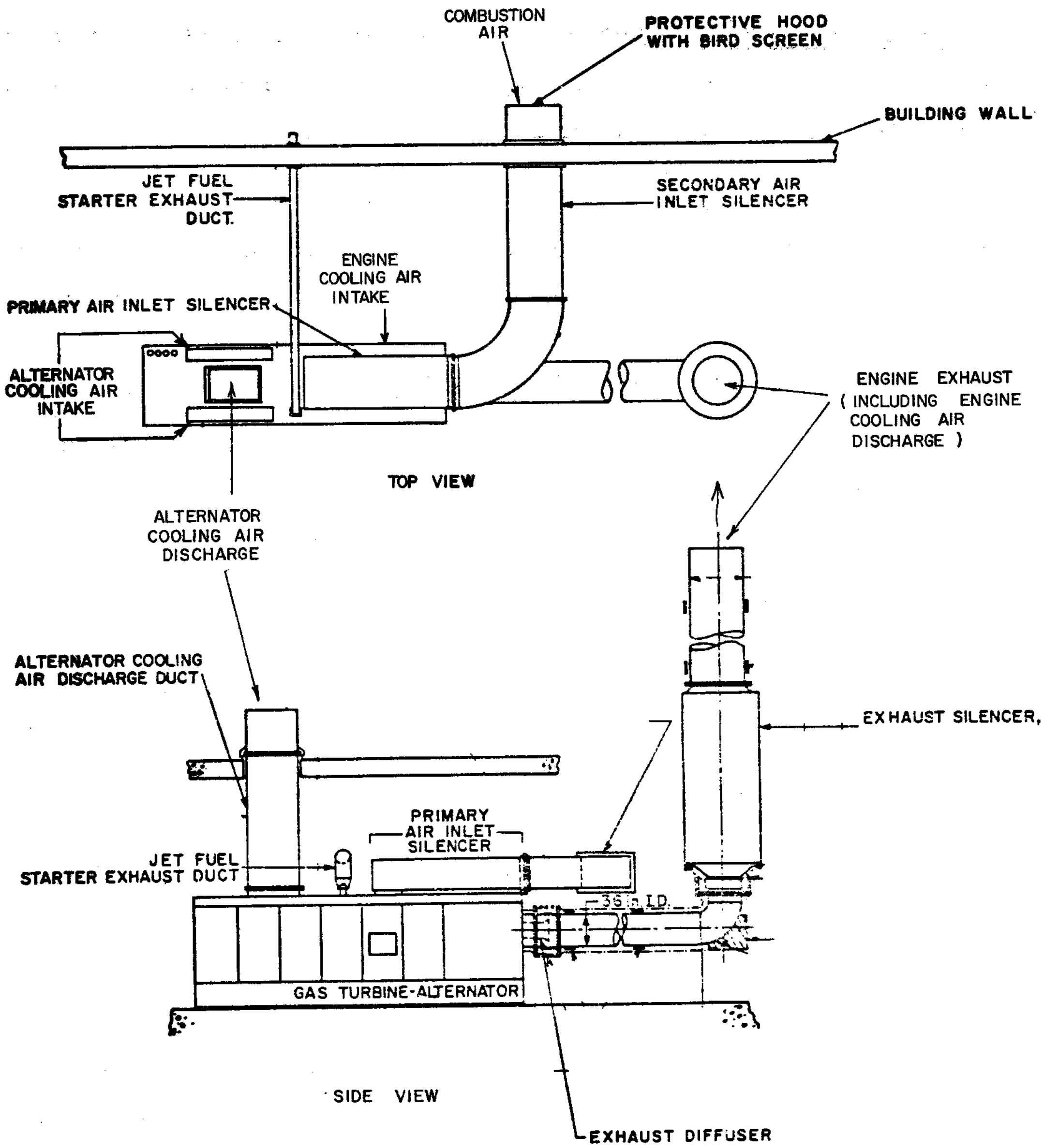


Figure 8.6 - Typical Gas Turbine-Alternator Installation

ing arrangements are available: (1) engine mounted radiator, (2) remote radiator and circulation system, (3) heat exchanger.

The set mounted radiator is pressurized and requires no water piping to the set. Standard radiators are provided with each set. When there is insufficient space available for provision of a set-mounted radiator and the associated air duct or there is no access to the outside air for exhaust of the heated air, a remote radiator may be provided. The Telephone Company equipment engineer must specify use of the remote radiator. Provision of the radiator and the associated pumps and piping is the responsibility of the Western Electric engineer.

Heat exchangers are no longer provided for use with diesel engine systems. Table H, section 5 of the AT&T Power Engineering Manual details the cooling system available for each of the engine sets which were available at the time of its publication. Detailed requirements for other sets may be obtained from the 802-XXX-XXX BSP's or the engine manufacturer.

8.13 Fuel Storage System

Virtually all gas turbine or diesel engine fuels are unsatisfactory for long term storage as delivered by the supplier. When properly treated with an inhibitor, the useful life of a fuel is anticipated to be 10 years.

A typical fuel storage and delivery system is shown in figure 8.7. Buried tanks are provided where day tanks alone are not adequate to provide the necessary reserve. In smaller installations, only a day tank would be required.

Fuel tanks are available in either buried or floor-mounted (day tank) arrangements. Typical sizes are shown in the Power Data book, section 6.93, sheet 6. Larger, non-standard tanks are also available.

Different fuels are usually required for diesel and gas turbine engines. However, when both types of sets are used in the same building, they may be operated from the same fuel supply (see BSP 065-320-301).

The Telephone Company equipment engineer is responsible for determining the size and type fuel storage to be provided. The architectural engineer is responsible for provision of a buried fuel tank and the fittings necessary to transport it to the building. Western Electric provides the associated pumps, day tank and building piping. All equipment required for day tank installations is provided by Western Electric.

Generally speaking, fuel tanks should be sized to provide three days reserve at the maximum fuel consumption rate for the engine(s) installed at the end of the design period. If the tank is already installed, the design period would be the end of power engineering period date. Keep in mind that the actual reserve in offices having a variable load would be somewhat greater than this calculated figure since the engine's maximum output (and fuel consumption rate) would not be expected for the full twenty-four hour period. If the buried tank is being newly installed, a ten year design period should be used.

In certain instances, a larger or smaller tank may be required:

- The minimum size day tank installed should be 275 gallons. National Fire Protection Association (NFPA) code 30 specifies that (1) if unenclosed, a tank (or tanks) of 550-gallon capacity may be installed or (2) if enclosed by a fire-protective wall (can be in the same room with an engine), the maximum installed day tank capacity is limited to 1100 gallons. Since local ordinances may further restrict the size of day tanks, installation should generally be limited to two 275-gallon tanks. Consideration may be given to providing only one day tank

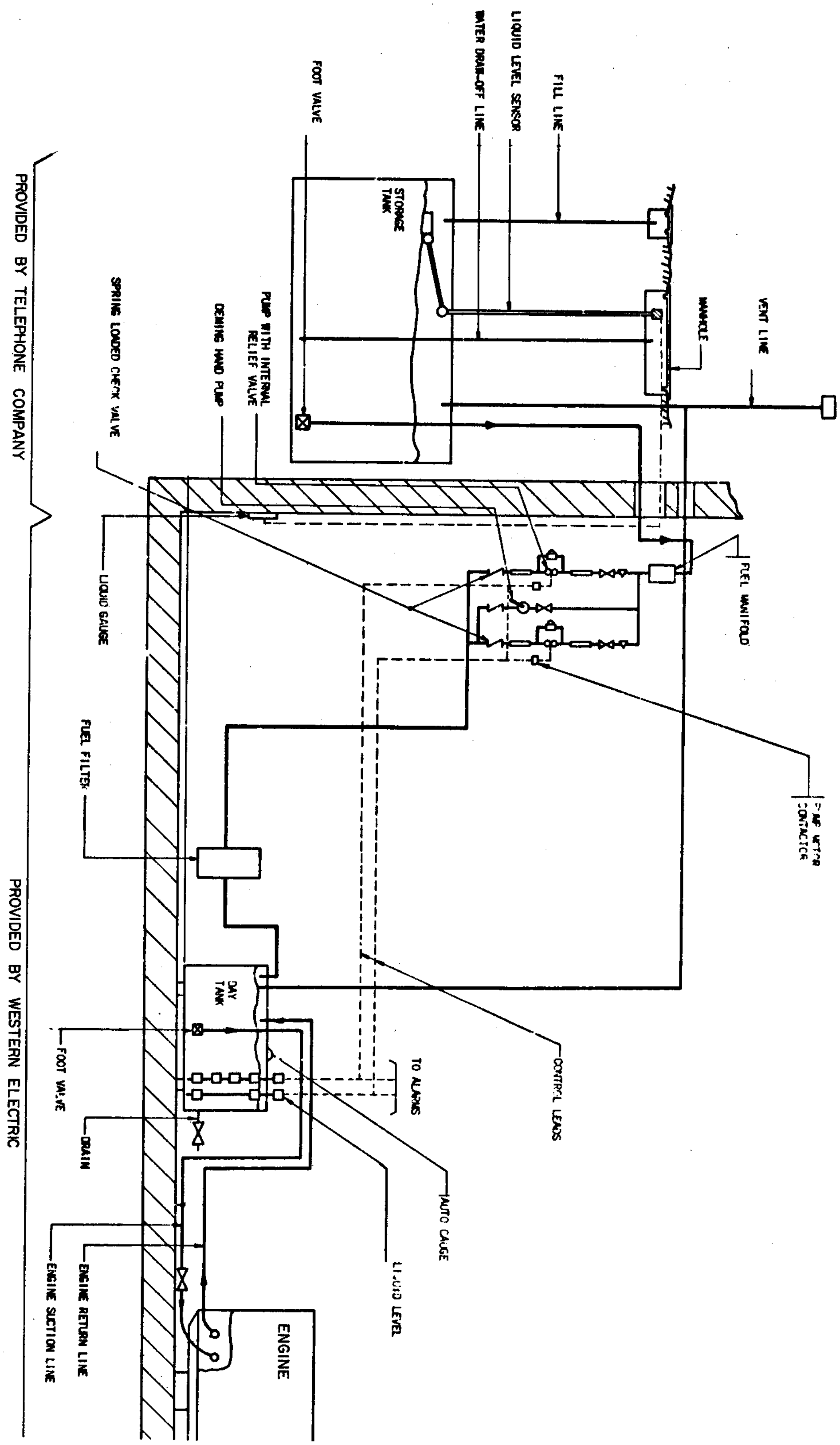


Figure 8.7 - Typical Fuel Equipment Arrangement Utilizing Buried Storage Tank

even though application of the three-day-reserve criteria dictates a requirement for two; if the projected end of design period KW load is small compared to the maximum output of the installed engine, only one day tank may be provided if the single tank is adequate to provide a three-day reserve based on the projected load.

- Accessibility of the office, especially during severe weather, may dictate a longer reserve.
- Availability of fuel may dictate a longer reserve.
- If the tank being added is the last one that can be installed on the site, then the design period should be the exhaust date of the building site.
- In some of the larger toll offices, a smaller reserve may be provided because of the limited space available for burying fuel tanks.

Using the above criteria, one 275-gallon day tank will always be provided for installations of engines having fuel, consumption rates of up to 3.82 gallons per hour (up to 30 KW). For engines having fuel consumption rates between 3.82 and 7.64 gallons per hour (40-75KW), two 275-gallon tanks should be provided. For larger engines, buried tanks should be considered whenever the fuel consumption rate for the design period engine exceeds 7.64 gallons per hour. As an example, the following emergency engine data has been determined:

	Present 9-72	End of Power Engineering Period 9-75	Estimated 1983
KW load	51.7	72.8	127
Engine Size, KW	60	200	200
Engine Type	Diesel	G.T.	G.T.

The existing 60 KW engine employs a 275-gallon day tank. There is not sufficient room in the basement to paralled the 60 KW with another engine. Therefore, a roof-mounted 200 KW gas turbine is being provided. There is room at the site for burying additional tanks. At the end of the power engineering period the engine will operate at 36.4% (72.8 X 100/200) of the full load. The following fuel consumption rates were taken from BSP 802-980-151:

Full load - 43.0 gals./hr.

3/4 load - 36.4 gals./hr.

1/2 load - 29.4 gals./hr.

1/4 load - 24.9 gals./hr.

0 load - 21.7 gals./hr.

Interpolating, the end of power engineering period fuel consumption rate would be:

$$24.9 \text{ gals./hr.} + \frac{.364 - .25}{.50 - .25} \times (29.4 - 24.9) \text{ gals./hr.} =$$

$$24.9 \text{ gals./hr.} + \frac{.114}{.25} \times 4.5 \text{ gals./hr.} =$$

$$24.9 \text{ gals./hr.} + 2.1 \text{ gals./hr.} = 27.0 \text{ gals./hr.}$$

Assuming use of a full 275-gallon day tank, this would provide us with a minimum 10-hour reserve (assuming a variable load). Since this is substantially less than the 72-hour objective and two day tanks will only provide a 20-hour reserve, a buried tank will be provided.

Since there is room at the site for burying additional tanks, the tank being installed should handle the projected load for the 10-year point, or 1983. At the full load fuel consumption rate for the 200 KW engine, the size fuel tank required would be:

43.0 gallons/hour (72 hours) - 275 gallons =

3100 gallons - 275 gallons = 2,825 gallons

From the Power Data book, section 6.93, sheet 6, a 3000-gallon tank would be provided.

In order to complete some fuel consumption calculations, 0 to full load fuel consumption rates may be required. For newer engines, 0 to full load fuel rates are given in the 802-9XX-XXX BSP covering each engine. The BSP's for older engines provide only the full load consumption rate. A second point for interpolation may be determined using actual load data for the engine.

When buried tanks are provided, the BSP's specify that a day tank is optional if the engine fuel pump is capable of pumping fuel directly from the buried tank to the engine. However, acutal experience indicates that considerable problems arise when no day tank is provided. Therefore, a day tank should always be provided when buried tanks are installed.

8.14 Reuse or Modification of Diesel Engines

When reuse of an engine at another location is proposed, it may be advisable to recondition the engine. Local engine distributors or factory representatives may be consulted for major engine service and reconditioning. Any reconditioning work should be charged back to the R account for the location from which the engine is being removed. The Telephone Company equipment engineer is responsible for providing Western Electric engineering with information about the removed engine. This responsibility can usually be satisfied by referencing the emergency engine T-drawing for the location from which the engine is being removed. This information is usually shown on a -590, -592 or AC block schematic drawing.

Sixty-KW emergency engines operating at 1200 r.p.m. can be modified to increase output to 100 KW. In some instances, it may be more economical to modify an engine rather than install a paralleling or replacing set. Newer 60 KW engines operating at 1800 r.p.m. cannot be modified for 100 KW operation. Table H, section 5 of the AT&T Power Engineering Manual lists the operating r.p.m. for most engines. A detailed cost estimate should be obtained from the firm engaged to handle the modification. This modification usually consists of:

- Replacement of the generator
- Replacement or modification of the control panel
- Enlargement of the exhaust system
- Engine reconditioning

For accounting purposes, the generator or alternator should be treated as a retirement unit and replaced on a C and X basis. Modification of the control panel and engine should be charged to M unless the entire control panel is replaced (replacement would be handled on a C and X basis). Repairs to the engine should be charged to R.

8.15 House Service Cabinet Terminations

The Telephone Company equipment engineer is responsible for advising the Western Electric engineer of the house service cabinet termination location (and transfer switch size) for an emergency engine. This information should be obtained from the architectural engineer.

8.16 Parallel Operation of Engines

Like or different size engines can be operated in parallel to provide the required AC backup. The new gas turbine generator sets may be operated in parallel with the standard diesel sets. A reverse current relay must be added to all emergency engine sets when two or more sets are operating in parallel. Limitations on parallel operation are contained in the 802-9XX-XXX BSP's covering the specific engine.

8.17 Engine Load Test Results

Results of annual load tests for diesel emergency engines are recorded on form S-6956 and forwarded at least once a year to the Engineering Department in accordance with procedures outlined in BSP 155-010-901SW. As discussed in part B, section 3.6, this load test should be made during the office busy season. A sample completed form is shown in figure 8.8. The "source of load" line should reflect the numbers of the house service cabinet switches transferred to the emergency bus at the time of the run. These switch numbers should be obtained by the Plant department from section V of the SWX-XXXX-550-G drawing for the office. Upon receipt of the form S-6956 in the Engineering department, it should be routed to the appropriate Equipment Engineer for review (see part B, section 3.5). After this review it will be forwarded to the Engineering library for filing in the "Power Drain Record" books.

Results of the three-month, full-load runs for gas turbines are recorded on form E-5697 and forwarded to the Engineering department in accordance with procedures outlined in BSP 155-002-010SW. A sample form is shown in figure 8.9. The "notes" column should reflect the numbers of the house service cabinet switches transferred to the emergency bus at the time of the run. These switch numbers should be obtained by the Plant department from section V of the SWX-XXXX-550-G drawing for the office. As outlined in part B, section 3.6, one of the full-load runs should be made during the busy hour of the office busy season. After review by the appropriate Engineering group, the form E-5697 should be filed in the "Power Drain Record" books.

8.18 Emergency Engine Data Entries, SWX-XXXX-550-G Drawing

The emergency engine data section (part IV) of the SWX-XXXX-550-G drawing is shown in figure

CENTRAL OFFICE EMERGENCY ENGINE SETS
PROLONGED LOAD TEST RESULTS

FORM S-6956 (Front)

155-010-901 SW — FORM S-6956

CENTRAL OFFICE EMERGENCY ENGINE SETS
PROLONGED LOAD TEST RESULTS

EXCHANGE ALPHA, MISSOURI OFFICE 721-723-725 DATE 2-14 1968

DATE INSTALLED SEPTEMBER 1961 OPERATED PER BSP 155-178-701

ENGINE DATA — SERIAL # 6A 95237

MODEL OR TYPE KS15890 L4

RATED H. P. 100 KW

MANUFACTURER GENERAL MOTORS

STARTS / RUNS: ☐ GAS ☐ — ☐ GASOLINE ☐ — ☒ KEROSENE ☒ — ☐ FUEL OIL ☐

COOLING: CITY WATER ☐ — RADIATOR ☒ — AIR ☐

FUEL DATA — GRADE 1D BRAND CONOCO AMT. USED 22 GAL.

OIL DATA — TYPE URSA HD SAE 30 BRAND CONOCO AMT. USED 1/2 QT.

GENERATOR DATA — MODEL OR TYPE # GENERAL MOTORS SERIAL # 294-11-60

RATED OUTPUT 100 KW AC ☒ DC ☐ MAX. B. H. OFFICE LOAD 76 KW

SOURCE OF LOAD POWER EQUIPMENT, BUILDING LIGHTS, AIR HANDLING UNITS / AC SWITCH NO.S 1,3,4,6

ENGINE STARTED AT 8 00 AM LOAD APPLIED AT 8 15 AM WAS TEST INTERRUPTED No

WAS OVERSPEED TRIP DEVICE OPERATION TESTED AND SATISFACTORY YES

READINGS AT HALF HOUR INTERVALS

TIME	A.M. OR P.M.	TEMPERATURE O.S.	ROOM #1	ROOM #2	ROOM #3	ENGINE HEAD	ENGINE CYL.	FREQ.	VOLTS PH. 1	VOLTS PH. 2	VOLTS PH. 3	AMPERES PH. 1	AMPERES PH. 2	AMPERES PH. 3	OUTPUT K.W.	NOTE NO.
8 30	A	60	78	78	74	170		60	220	220	220	220	260	240	76	
9 00	A	50	82	78	75	172		60	220	220	220	205	250	220	72	
9 30	A	50	82	78	75	172		60	220	220	220	190	230	210	70	
10 00	A	55	83	79	76	172		60	218	218	218	205	250	220	75	
10 30	A	60	84	80	77	172		60	218	218	218	200	250	220	75	
11 00	A	60	84	80	77	172		61	220	220	220	190	235	210	70	
11 30	A	60	85	81	78	172		61	220	220	220	190	240	210	70	
12 00	N	60	84	80	77	172		60	220	220	220	185	230	200	68	
12 30	P	60	84	80	77	172		60	220	220	220	200	240	215	72	
1 00	P	62	82	78	75	170		60	220	220	220	200	235	215	72	
1 30	P	65	82	78	75	170		61	219	219	219	200	245	220	73	
2 00	P	65	82	78	75	170		60	220	220	220	190	235	210	70	
2 30	P	65	82	78	75	170		60	220	220	220	205	245	220	74	
3 00	P	65	82	78	75	170		60	220	220	220	250	270	260	76	
3 30	P	65	82	78	75	170		60	220	220	220	250	270	260	76	
4 00	P	60	82	78	75	170		60	220	220	220	200	245	220	73	

TEST PERFORMED BY John Smith TITLE Switchman

RESULTS REVIEWED BY Jack Brown TITLE Chief Switchman

Figure 8.8 - Sample Form S-6956

E-5697 [illegible]
PRINTED IN U.S.A.

TURBINE RUN LOG

OFFICE ______
LOCATION ______
FUEL TANK CAPACITY ______ GALS.
ENG. MFR ______
RATING ______ KW.
ENG. NO. ______
MODEL ______
KS ______ LIST

DATE & TIME	ENG HOUR METER	TEMP.			FUEL PRES. ΔP	ENG. SPEED %	FREQ	KW LOAD	AMPERES			VOLTS PHASE 1 - 2						FUEL GAUGE READ	REAS. FOR OPER	OPER BY	NOTES
		ROOM	COMP. INLET	EXH GAS					1	2	3										NOTE NORMAL REQUIREMENTS

NOTES

Figure 8.9 - Turbine Run Log

8.10. The engine data for installed engines (part IV A) may be taken from the Western Electric T drawings (590, 592 or AC block schematic) and section 6 of the Power Data book. If no stationary engine is installed, part IV A should reflect the size and availability of a portable emergency engine: A 5 KW portable engine is available in Alpine.

Part IV B should be completed using information outlined in part B, section 8.17 of this practice.

Part IV C should be completed using procedures outlined in section 8.3 of this practice. The "other" entry should be used to record both miscellaneous telephone equipment and building load. This part should be completed even if no emergency engine is installed. The load data may be used by Plant personnel in determining the adequacy of the available portable emergency engines and in completing form SW-6438 (see V61.032).

Part IV D should be completed using procedures outlined in section 8.13 of this practice. Remember that the hours of reserve will be understated if the office experiences a variable load (i.e., the end-of-engineering period KW load computed in part IV C would not be experienced for the full 24-hour period).

The standard format of the 550-drawing may be used in most cases to record all information pertaining to the emergency engines. However, the format may have to be modified to record all information for larger offices.

8.19 Engineering Responsibilities

Certain engineering determinations must be made regardless of whether the emergency AC supplies are diesel or gas turbine driven. Other considerations depend on the type of engine. The table shown in figure 8.11 outlines engineering responsibilities for both the Telephone Company architectural and equipment engineers, indicates whether it is jointly determined and whether it applies to diesel and/or gas turbine installations. When responsibility is assigned to the architectural engineer, it may mean that the actual determination is made by the consulting engineer.

IV EMERGENCY ENGINE DATA

A ENGINE DATA

KS NO.	OUTPUT			AUTO OR MANUAL		INSTALLED	
	AC VOLTS	PHASES	KW	START	TRANSFER	SPEC	DATE
15884	208 - 240	3 Ø, 4W	60	MANUAL	MANUAL	4431.72	10 - 68

B. LATEST LOAD DATA (FORM S-6956)
1. DATE 9-25-72 ; PEAK KW LOAD (ALL ENGINES) 44
2. HOUSE SERVICE CABINET SWITCHES TRANSFERRED TO EMERGENCY BUS AT TIME OF RUN (SWITCH NO.'S FROM SECTION V): # 1

C. LOAD DATA, END OF POWER ENGINEERING PERIOD

SOURCE	DC AMP	KW
-48 V PLANT(S)	220	16.5
+130 V PLANT(S)	90	18.0
-24 V PLANT(S)	50	1.9
V PLANT(S)		
V PLANT(S)		
V PLANT(S)		
INVERTER PLANTS [1]		5.75

SOURCE	DC AMP	KW
EMERGENCY LIGHTING (V)	10	0.8
SUMP PUMP & ELEVATORS	—	2.5
VENTILATING & EXHAUST FANS		5.6
AC OPERATED RINGING MACHINE [2]		—
COMPRESSOR-DEHYDRATOR		0.4
OTHER (LIST)		—
TOTAL		51.45

NOTES: [1] IF PLANT SERVED FROM EMERGENCY ENGINE, ENTER AC KW INPUT. IF NOT TRANSFERRABLE, ENTER KW FOR DC INPUT.
[2] TRANSFERRED TO DC UPON COMMERCIAL POWER FAILURE

D. FUEL RESERVE, END OF POWER ENGINEERING PERIOD

1. INSTALLED CAPACITY, DAY AND BURRIED TANKS, GALS — 275
2. FUEL CONSUMPTION, POWER ENGR. PERIOD, GALS/HR — 5.9
3. HOURS RESERVE, POWER ENGR. PERIOD LOAD (FROM III C), FROM FULL TO EMPTY TANK (1 ÷ 2) — 47

Figure 8.10 - Emergency Engine Data Entries, SWX-XXXX-550-G Drawing

Item	Resp.		Applies To:		Section
	Arch.	E.E.	Diesels	Gas Turb.	No.
1. Items to be tied to emergency AC bus	X	X	X	X	8.3
2. Determining load and sizing engine		X	X	X	8.3
3. Portable or stationary operation		X	X		8.4
4. Diesel or gas turbine operation, where applicable		X	X	X	8.6
5. Location of engine and associated equipment	X	X	X	X	8.6
6. Should fire wall be provided	X		X	X	8.6
7. Engine output voltage		X	X	X	8.7
8. Manual or automatic start and load transfer		X	X	X	8.8
9. Sizing air intake louvers and filters	X		X	X	8.10, 8.11
10. Sizing exhaust flue or stack	X		X	X	8.10, 8.11
11. Sizing auxiliary ventilating equipment	X		X	X	8.10, 8.11
12. Sizing exhaust louvers	X		X	X	8.10, 8.11
13. Remote or engine-mounted radiator	X	X	X		8.12
14. Size and type (buried and/or day) of fuel storage tank		X	X	X	8.13
15. Location of fuel tanks	X	X	X	X	8.13
16. Recondition and/or modify engine		X	X		8.14
17. House service cabinet termination for emergency engine	X	X	X	X	8.15
18. Employing parallel operation of engines	X	X	X	X	8.16
19. Preparation of 550-G drawing		X	X	X	8.18

Figure 8.11 - Emergency Engine Engineering Responsibilities

PART B - SECTION 9.0

AC POWER PLANTS AND CONVERTERS

9.1 Introduction

In addition to rectifiers and motor-generators, telephone equipment requires use of other forms of power supplies: AC-to-AC (transformers), DC-to-AC (inverters), and DC-to-DC (converters). While not widely used, AC power plants do serve an important function in providing certain types of telephone service. The AC power plants usually derive their prime input source from either the commercial power supply or from DC power plants (inverters). In some AC power plants using the commercial power supply as the primary input source, a backup DC-to-AC source may be incorporated in the plant to insure continuous service during commercial power failures. Some of the more common types of equipment requiring AC input are clocks, calculagraphs, AMA equipment, TH radio and terminal equipment and L carrier equipment.

DC-to-DC converters, as the name implies, are normally used to convert one DC voltage to a different DC voltage but may also be used to isolate equipment from a common power (and noise) source (as in the case of L Carrier). They are used as a source of DC power where the amount of DC power required for a particular voltage is small, and a separate complete DC power plant for the needed voltage is not economically justifiable. Of course, a DC plant of a different voltage must be available to serve as the primary input source. The most prevailing use of converters is in furnishing 130-volt power for carrier systems from a 48-volt plant. There are, however, many other uses and conversion voltages used.

DC-to-DC converters are also incorporated as a part of some rectifier-type power plants to provide for continuous service during a rectifier failure.

9.2 AC Power Plants

The 500-type plants are a series of AC output plants that are manufactured by the Western Electric Company under standard J codes for Telephone Company use. The currently available plants are listed in BSP 802-000-000. BSP 802-001-151 and Section 4 of the AT&T Power Engineering Manual list some of the available plants and their applications. The individual plant BSP's should be referred to for detailed information.

Selection and sizing of 500-type plants is a little easier than engineering other types of power plants because most 500-type plants have been designed for a specific application. It is the Telephone Company engineer's responsibility, however, to specify the type and size of all AC power plants that are required and to outline their use in the Telephone Company specification.

The size of the plant needed depends on the drain requirements of the load; in some instances more than one plant may have to be provided. The plant is sized by calculating the total drain of all equipment that will be connected to the plant under load conditions. In general, an AC power plant is sized to last the life of the office or the equipment entity it serves. In some cases, it is permissable for an AC plant to serve more than one equipment entity. In such cases, the cost savings should be weighed against the service hazard involved. For instance, a TSPS and ETS unit might share the same plant if their loads permitted.

Supplements B and C to section 4 of the AT&T Power Engineering Manual show two typical arrangements of 500-type plants being used to serve a No. 5 crossbar office, and L and TH equipment. Supplement B also shows an example in which the input source of one 500-type plant is derived from the output of another 500-type plant. In this instance, a 506-A plant is fed from a 504-B because the 506-A is not equipped with a back-up supply, while the 504-B is arranged with a -48 volt inverter for emergency service. Whether the AC power plant chosen needs an emergency input back-up source or not depends upon the operating requirements of the equipment being served. Some of the larger, older 500-type plants use DC motors to drive alternators during power failure.

The AC input for 500-type plants served by commercial AC should either be obtained from the house service cabinet, the power service cabinet, or bus duct if transfer to the emergency engine is required during power failures. The house service cabinet should be used when the 500-type plant is to be transferred to the emergency bus only during actual power failures and not during routine engine runs (the AC supplied to customer call timing equipment falls into this category).

The space occupied by the 500-type plants varies from a few mounting plate spaces to one or more cabinets, depending upon the code and capacity. The Telephone Company engineer is responsible for the floor plan layout for the cabinet type. The Telephone Company engineer is also responsible for insuring that proper AC input voltage and fuses are available, if AC is required. The Telephone Company engineer must also insure that the battery reserve is sufficient to power the AC plant during an AC failure if the plant is arranged to transfer to a back-up DC source during the failure. This drain is included as part of the power failure drain when sizing batteries. If the AC circuit serving a power plant is to be transferred to the emergency bus during a power failure, then this drain should be used in sizing the emergency engine.

9.3 Converters

The majority of converters used in telephone applications are the 600-type plants manufactured by the Western Electric Company. These plants use DC-to-DC transistorized converters which transform the input DC voltage to other DC voltages. They are installed where relatively small amounts of power at other voltages are required, and where sufficient DC plants are available for their operation. The currently available plants are listed in BSP 802-000-000. BSP 802-001-151 and Section 2 of the AT&T Power Engineering Manual list some of the available plants and their applications. The individual plant BSP's should be referred to for detailed information.

The most widely used input voltage is -48 volts, but some converters require a -24 volt input.

The use of converters is on the upswing since more and more circuit equipment is designed to operate from 48 volts, and the required amounts of other voltages decreases. This means that converters can be used more economically than separate battery-type power plants to furnish these other voltages. Converters have also become widely used as a coin control supply, and superimposed and trip battery supply in central offices.

The choice to provide a converter rather than a separate power plant depends upon the following items:

1. Forecast of drain requirements
2. Availability of adequate DC input power
3. Economics

The present drain requirements for a particular voltage will indicate whether or not a converter can even be considered, since the available converters have stated upper limit output capacities. If the present drain requirement is in limits, then the long range forecast should be studied to determine how long the converter plant will be capable of handling the drain. An economic study will usually be required if indications are that the converter plant will not be adequate through the long range forecast.

When downgrading a toll center to CDO operation, consideration should be given to replacing the existing 24-volt plant with converters.

The biggest disadvantage in using a converter is the amount of input DC power required in relationship to the amount of output power derived (the converter is relatively inefficient). Therefore, it is vital that the adequacy of the power plant that is to furnish the input power be checked, especially in small offices or repeater stations. In those cases where the supply plant is not adequate, the choice lies between providing a separate battery power plant or replacing the supply power plant with one of a larger capacity. A review of the forecasted drain requirements for the input source plant and the economics involved will ensure selection of the proper plant. The BSP's for the plants under consideration will usually indicate the amount of input power required for a specific output load.

The availability of floor space should also be considered when deciding between a converter plant or a separate battery plant. Most converter plants require no more than one bay, while a separate plant will require at least one or more bays plus a battery stand.

Converters are widely used in independent company locations to power toll circuit equipment. The Telephone Company engineer is responsible for verifying that the independent company can furnish an adequate amount of power from their power plant. The independent company is reimbursed periodically for this power and this cost should be taken into account when deciding between a converter and a separate power plant.

If a converter plant is to be used, the Telephone Company engineer is responsible for specifying the code and the capacity of the plant to be furnished. Provision of maintenance spare converters may be considered only if the plant is arranged for load sharing or automatic switching of the load (since little service protection is afforded if the maintenance spare rectifier has to be switched into service manually). If the plant is arranged for load sharing, consideration should be given to the cost of the increased converter DC input requirements (per amp of output). In those cases where a converter serves to back-up a rectifier (as the Lorain 1271A plant), neither a spare rectifier or converter will be provided unless the plant switching features do not permit load transfer (from rectifiers to converters) under all out-of-service conditions (both commercial AC and system component failure).

As previously mentioned, converters are also used as a supply source for coin control, and superimposed and trip battery. Before converters were available, these supplies were generally obtained from dry cell batteries or rectifiers. The dry cell arrangement is expensive to maintain (since the dry cells require periodic replacement in order to maintain the proper potential) but is still found in many older offices. There is no planned program to replace the dry cell batteries with converters, but if the maintenance expense in a location is excessive, it can be justified from an economic standpoint. Newer ringing plants use converters for these power supplies. Some of the ringing plants do not incorporate these converters directly as part of the ringing plant, but specify that they shall be mounted in a separate bay (the ringing plant BSP covers this item). It is the responsibility of the Telephone Company engineer to specify the code and size of the converter when a replacement is involved. On new or replacement installations of ringing machines, the Telephone Company engineer need not specify the type of converter if it is an integral part of the ringing machine or is specified in the ringing maching BSP.

There are occasions where the application of a 600-type plant is not practical, and in some cases not possible because of the voltage required. In these instances, it may be desirable to use a converter manufactured by an outside supplier. Descriptions of outside supplier KS-coded converters may be obtained from the Power Data book. Outside supplier catalogues may be used to obtain information about the non-KS converters. These catalogues will also show which of a manufacturer's plants can be obtained under a KS specification.

9.4 AC Power Plant and Converter Entries, SWX-XXXX-550-G Drawing

The AC power plants and DC-to-DC converters installed in an office should be recorded in section VI of the SWX-XXXX-550-G drawing as shown in figure 9.1.

Figure 9.2 outlines information which may prove helpful in entering data for 500-type plants. The information shown is for the most frequently found plants. For other plants, this information may be obtained from the BSP's, the Power Data book, the List 1 Current Drain Book, etc.

VI AC POWER PLANTS AND CONVERTERS

CODE	SIZE[1]	OUTPUT VOLTAGE	DC INPUT VOLTAGE	AC INPUT ON EMERG. ENG.[2]	DESCRIPTION OF LOAD	INSTALLED	
						SPEC	DATE
504B	1.5 KW	115	-48	YES	AMA. EQUIP., 506 PLANT	4431.72	10-68
506A	0.75KVA	22	—	NO	CALCULAGRAPHS	4431.72	10-68
610B	1.5 A	± 120	-48	—	COIN CONTROL	4431.90	7-70
LOR. CSTS	5 A	-130	-48	—	N1 CARRIER	4431.98	12-70

NOTES: [1] FOR CONVERTERS, SHOW TOTAL INSTALLED CAPACITY INCLUDING STANDBY.
[2] FOR INVERTERS, ENTER YES OR NO IF PRIMARY POWER SOURCE IS AC.

Figure 9.1 - AC Power Plant and Converter Entries, SWX-XXXX-550-G Drawing

PLANT	USE – B.S.P.	PLANT SIZE	AC KW IF ON EMERG BUS	TRANSFER TO DC DURING PWR FAILURE	DC BACKUP			
					TYPE	VOLTAGE	DRAIN	BASIS FOR ESTIMATING DC DRAIN
501A (STD)	SWITCHBOARD LAMPS (802–801–150)	5-8.5V	NOTE 1	NO	—	—	—	—
		5-11.5V	NOTE 1					
504B (STD)	NO. 5 & ESS OFFICE AC REQUIREMENTS (802-802-161)	0.5KVA	0.4^2	YES	DC MOTOR DRIVEN ALTERNATOR	-48	NL-6.5 AMPS FL-17 AMPS	% EQUIPPED VS FUSE CAPACITY OF THE PLANT
		1.5 KW	1.5^2			-48	FL-66AMPS	
		5.0 KW	5.0^2			-48	FL-220AMPS	
505 C (MD)	L1 CARRIER (802-804-151)	1.5 KVA	1.2^2	YES	DC MOTOR DRIVEN ALTERNATOR	130	24 AMPS FULL LOAD	ASSUME FULL LOAD
		2.5KVA	2.0^2			130	40 AMPS FULL LOAD	ASSUME FULL LOAD
505 D (STD)	L3 CARRIER (802-804-154)	10 KVA	8.0^2	YES	DC MOTOR DRIVEN ALTERNATOR	130	NL- 22 AMPS 1/2- 57 AMPS 3/4- 77 AMPS FL -165 AMPS	USE 802-804-154 PAR 1.04 TO CALCULATE LOAD
		16 KVA	12.8			130	NL- 36 AMPS 1/2- 93 AMPS 3/4-129 AMPS FL.-165 AMPS	USE 802-804-154 PAR 1.04 TO CALCULATE LOAD
506A (STD)	CALCULAGRAPH SUPPLY (802–805–150)	50VA 1.5KVA	NOTE 3	NO	—	—	—	—
507A (STD)	CALCULAGRAPH SUPPLY (802–806–150)	50VA	$.16^2$	YES	VIBRATOR	-48	1.3 AMPS FULL LOAD	$\frac{\text{\# CALCULAGRAPHS}}{20}$ X FULL LOAD DRAIN
						-24	2.8 AMPS FULL LOAD	

Figure 9.2 - Typical 500-Type Plants

Figure 9.2 (cont) - Typical 500-Type Plants

PLANT	USE- B.S.P	PLANT SIZE	AC KW IF ON EMERG BUS	TRANSFER TO DC DURING PWR FAILURE	DC BACKUP			
					TYPE	VOLTAGE	DRAIN	BASIS FOR ESTIMATING DC DRAIN
508A (M.D.)	TH MICROWAVE (802-806-160)	5KW	5.5^2	YES	DC MOTOR DRIVEN ALTERNATOR	130	N.L.-11 1/2-36 3/4-43 F.L.-55	ASSUME FULL LOAD
520A (A&M)	TH MICROWAVE - OPERATES FROM 152V, 413A PLANT CONTINUOUSLY UTILIZES INVERTERS (802-810-180)	230V	—	NO, OPERATES FROM 152V, 413A DC PLANT	—	—	—	—
523A	CRITICAL AC LOADS (802-813-150)	1.5KW	1.5^2	YES	INVERTER	-48	N.L.- 7.5 1/4L-14.5 1/2L-21.5 3/4L-30 FL-37.5	$7.5 + \left[\frac{E}{150}(30)\right]$ WHERE E IS TOTAL EQUIPPED DISTRIBUTION FUSE CAPACITY
524A (STD)	CRITICAL AC LOADS (802-814-150)	5 KW	5.0^2	YES	INVERTER	-48	N.L.-22.0 1/4L-46.0 1/2L-72.0 3/4L-98.0 FL-125.0	$22.0 + \left[\frac{E}{270}(103)\right]$ WHERE E IS TOTAL EQUIPPED DISTRIBUTION FUSE CAPACITY.

NOTES:
1. ASSUME .08KW FOR 11.7 AMP UNIT; 0.4KW FOR 59 AMP UNIT; 1.19 KW FOR 174 AMP UNIT; 1.6KW FOR 236 AMP UNIT
2. ASSUME 0.8 POWER FACTOR
3. NORMALLY REFLECTED IN THE LOAD OF THE SERVING 500-TYPE PLANT (AS 504B) WHICH MAY OR MAY NOT BE ON THE EMERGENCY BUS (SEE AT&T POWER ENGINEERING MANUAL, SECTION B FOR A TYPICAL DIAGRAM)

PART B - SECTION 10.0

RINGING MACHINES

10.1 General Description - Ringing and Tone Requirements

The ringing power plant generates certain ringing and tone outputs which are essential for operation of telephone equipment. These outputs can be categorized as follows:

Ringing current - 20 HZ output furnished for ringing subscriber's sets.

Tone current - used to audibly transmit circuit conditions (as dial tone).

Interrupted signaling current - certain ringing or tone currents are interrupted at periodic intervals where required to perform certain central office functions (60 or 120 IPM tones; ring and silent intervals for machine ringing).

Coin control current - this positive and negative DC current is used to control the coin collect and return operations of a pay station (in prepay locations). In some older plants the coin control current was supplied from dry cells or a separate rectifier in the ringing plant. Presently, separate DC-to-DC converters are provided for this purpose (see part B, section 9.3).

10.2 Ringing Systems

Both manual and machine ringing systems are in use. In manual systems (used primarily in small PBX's), a continuous ringing current is generated. The duration of the ring period is controlled by the PBX operator via operation of a ring key located on the switchboard.

In a machine ringing system (used in central offices and larger PBX's), ringing, once started, is continued automatically until the call is either answered or abandoned. The ringing starts as soon as connection is made to the called subscriber's line. The ringing current flows through a tripping relay circuit which, when the subscriber answers, operates and discontinues the flow of ringing current to that line.

Depending upon the type system employed, the following types of ringing may be employed:

Individual ringing- type of ringing used to alert individual subscribers or stations.

Selective ringing (2 or 4 party) - a party-line system which permits ringing the set of only the desired party.

Semi-selective ringing (4 and 8 party) - a party-line system which rings the sets of two parties simultaneously. Party differentiation is by means of a one-ring, two-ring code.

Code ringing - a system in which the number or duration of rings, or both, indicate which party is being called.

A complete description of ringer arrangements for the above types of ringing is included in BSP 975-110-100.

Early machine ringing plants employed a 20 HZ current for ringing functions. Later a DC component was added to improve operation of the trip relay during the ring interval of the ringing cycle. All newer plants provide superimposed ringing which employs alternating ringing current superimposed on direct current. As shown in figure 10.1, this results in a pulsating current. The ringing current is superimposed on both a positive and negative battery to obtain positive and negative pulsating current. The subscriber's ringers are so constructed and adjusted that each will respond to only one polarity of superimposed current. By connecting a ringer responding to negative current and another responding to positive from one side of the line to ground, and two more similar ringers from the other side of the line to the ground, four-party selective ringing is accomplished. By doubling the number of ringers and employing one and two ring alerting, eight-party semi-selective ringing is obtained. Where one and two-ring semi-selective machine ringing is used, a pickup circuit arrangement guards against the false ringing of the two-ring subscribers. In some instances (involving superimposed plants and tube-type subsets), an improperly shaped ringing current wave may result in failure of the ringing current to properly break down (and ring) the subset (telephone) tube.

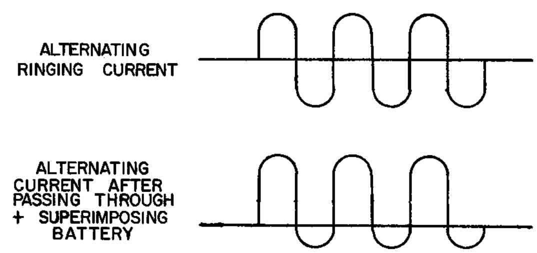
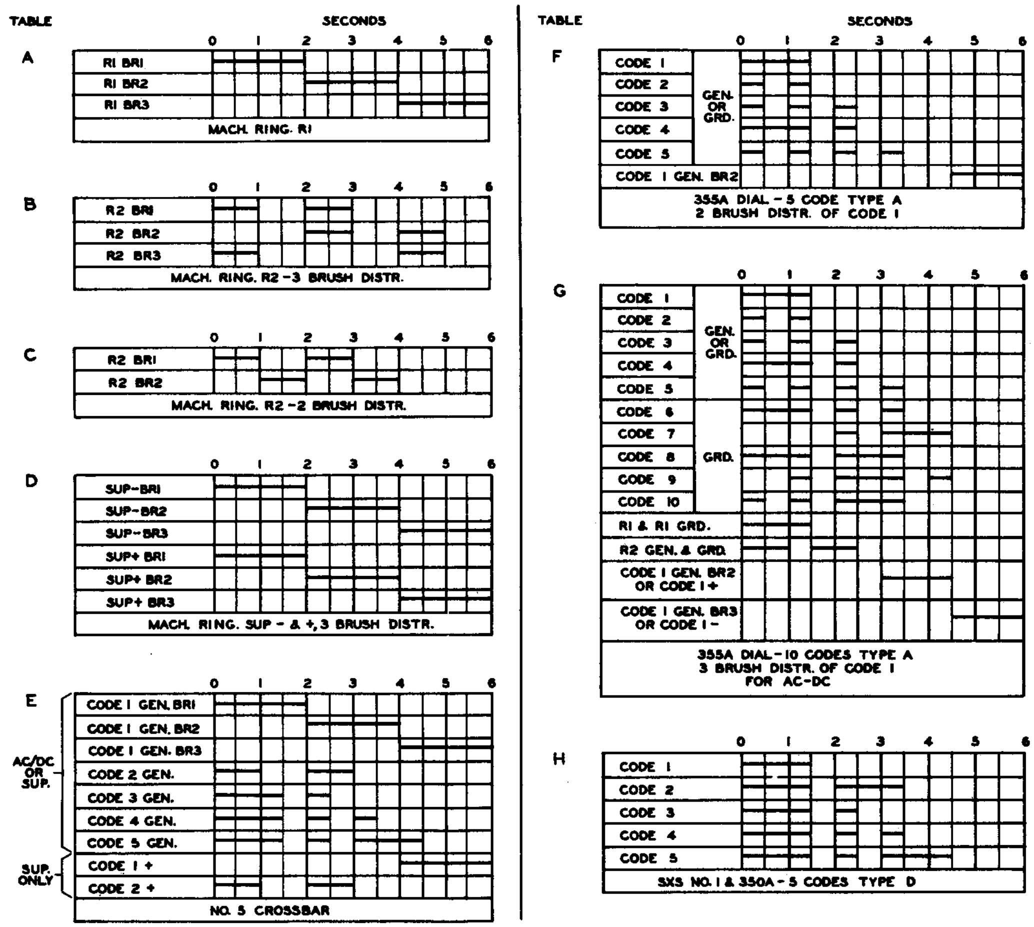


Figure 10.1 - Comparison of AC and Superimposed Ringing Wave Forms

Ringing current is supplied by machine ringing interrupters designed to provide the proper ring and silent intervals required in the office. Figure 10.2 (taken from BSP 802-004-152) shows some of the types of machine ringing that are available. The types of ringing available from a specific plant are shown on the SD drawing for that plant. This table points out that type A ringing of either 5 or 10 codes is used in 355 SXS offices while type D is to be used in No. 1 or 350 SXS offices. When replacing a plant in a 355 office, a replacing ringing plant can be ordered with either type A or D ringing. If the conversion from type A to D is planned, this change will have to be coordinated with the Commercial Department to insure customer notification. All new ringing plants in offices other than 355's equipped with type A for which no conversion is planned should be equipped with type D codes.

The division of the ringing load in machine ringing offices is accomplished by means of slow-speed interrupters. Since the ringing interval is usually only one half as long as the silent interval (usually 2 seconds and 4 seconds respectively), it is possible to utilize three slow-speed interrupter



TYPE OF RINGING	TABLE
INDIVIDUAL AND 2 PARTY SEL. AC/DC	A
4 PARTY SEMI-SEL. AC/DC	A & B OR A & C
4 PARTY FULL SEL. SUPERIMPOSED	D
NO. 5 CROSSBAR AC/DC OR SUPERIMPOSED	E
355A DIAL-5 CODE-AC/DC	F
355A DIAL-10 CODE-AC/DC OR SUPERIMPOSED	G
SXS NO. I AND 350A-5 CODE TYPE D	H
8 PARTY SEMI-SEL.	CODES I & 2 GEN. OR GRD.

NOTE:
OTHER COMBINATIONS OF RINGING INTERRUPTIONS ARE SHOWN ON POWER RINGING CIRCUITS FOR THE VARIOUS RINGING PLANTS.

Figure 10.2 - Typical Machine Ringing

units in an arrangement whereby one-third of the office is supplied ringing current during a two-second ringing period, another third of the office during the next two seconds and the final third during the last two seconds. Thus the ringing generator can carry three times the load it could handle if the whole office were supplied during the same two-second ringing period.

10.3 Tones and Interrupted Signals

Tones are used to audibly transmit circuit conditions to subscribers or operators and are usually classified as either high or low tones. In certain instances they are furnished as continuous tones (as dial tone). In other cases the tones are uniformly interrupted (as busy or all-trunks-busy tones). Howler tone is also provided to attract the attention of a subscriber when he leaves the receiver off hook.

Early, small ringing plants used a static (no moving parts) generator for obtaining ringing current and tones (many 355 offices are still equipped with static generators). A separate AC driven interrupter was also required to provide the necessary interrupted tones. Larger ringing plants employed an AC driven generator for both ringing current and tones. Interruption was provided via an interrupter driven by the ringing machine shaft via reduction gears.

The advent of No. 1 ESS required development of a new type of ringing plant which is used to generate "precision" tones. This system employs solid state oscillators to generate the four types of tones required in the office:

Touch-Tone dial tone

Audible ringing tone

High tone

Low tone

Early precision tone plants used solid state generators but employed motor driven interrupters. The newest plants available for use employ a solid state interrupter.

Precision tones have distinct advantages from a transmission and noise standpoint. They are also much more adaptable to the addition of new features in existing switching systems. Presently, solid state plants capable of providing precision tones are available for all switching systems and should be used whenever a new ringing plant is required. In some small office applications (where replacement is required for some other reason than capacity), use of the solid state plant may not prove to be economical because of the high first cost of a solid state machine. The economic techniques outlined in part B, section 2.2 may be used in selecting ringing machines for a specific application. Figure 10.3 shows the component frequencies for a precision tone plant.

A complete description of all ringing tones is contained in BSP 800-610-165.

10.4 Standard Ringing Plants

Figure 10.4 lists all standard ringing plants presently in service or available for use. This list updates information included in BSP 802-001-151. In addition many small 355 offices still utilize a ringing shelf (.25 amp, J86212) for ringing and tone supply. Detailed information about each of these plants are included in the BSP's referenced in this list

Sufficient room has been left at the bottom of the third page of figure 10.4 to list new plants as they become available.

Tone	Frequencies (HZ)
Touch-Tone Dial Tone	350 + 440
Audible Ringing	440 + 480
High Tone	480
Low Tone	480 + 620
Line Busy Tone	Low tone at 60 ipm
Paths Busy Tone	Low tone at 120 ipm

Figure 10.3 - Component Frequencies, Precision Tone Ringing Plant

10.5 Automatic Transfer Arrangements

In order to ensure uninterrupted service during a ringing machine failure, all ringing plants are equipped with two supplies.

Automatic switching from the regular to a reserve ringing supply is employed in most of the larger plants. While the detailed circuit arrangement may differ with various sizes and types of plants, this feature provides for starting the reserve battery driven machine when the voltage of the regular AC or DC driven generator falls below a predetermined value (usually caused by a primary power supply failure or other trouble). The ringing supply, tone and interrupted signal circuits, are transferred from the regular generator to the reserve generator by means of an electrically operated transfer switch. When ringing current of the proper voltage from the regular generator becomes available, the supply circuits may be arranged for transfer of the load back to the primary generator.

10.6 Ringing Plant Tone Distribution

The various tones generated by a ringing plant are fed from fuses mounted on the main ringing power board. These main fuses will in turn feed other distribution bays or equipment fuse panels.

For instance, in SXS offices, the main fuses feed the miscellaneous fuse bays (located in the equipment room) from which individual circuit tone power is obtained (the same miscellaneous fuse bays from which -48V, +130V, etc., power is obtained). In No. 5 crossbar offices, the main ringing tone fuses feed power and ringing tone distribution bays (PRTD) located in the equipment room. In No. 1 ESS offices, the ringing and tone bay is located in the equipment room and feeds the equipment bays directly.

On EF&I jobs, Western Electric engineering is responsible for providing and sizing all ringing

RINGING PLANTS

PLANT CODE	SPEC. NO.	802- B.S.P.	VOLTAGE	MAX. AMP CAPACITY	APPLICATION
801E	J86458	901-150	101-110	0.5	20 HZ ringing supply for toll or as a PBX feeder supply
802B	J86523	901-156	4.25	.025	1000 HZ signaling current for testing and ringing over toll and long distance circuits
803C	J86555	902-151	84-88 115-120	6 0.5	20 HZ ringing supply for panel; #1, #5 X-bar; large SXS; No. 4 and 4A switching systems
804C	J86451	902-157	84-88	1.0	20 HZ machine ringing and signaling supply for #1 and No. 5 crossbar, #1 and 350 SXS systems
804D	J86477	902-158	84-88	1.0	Portable 20 HZ machine ringing and signaling supply for emergency use
806D	J86596	904-151	72-88 75-110 65-90 90-130 110-130	0.25 0.50	20 HZ machine ringing and signaling supply for #1, 350A, 355A, 35E97 SXS offices and in large 701B and 711B PBX's
806E	J86445	904-152	84-88	0.25	20 HZ ringing supply for 355 and 356 SXS offices
806F	J86456	904-153	84-88	0.25	20 HZ ringing supply for 355 SXS and #5 X-bar offices
806G	J86472	904-154	65-90	0.25	20 HZ ringing supply for 701B, 711B and 740E PBX's

Figure 10.4 - Standard Ringing Plants

RINGING PLANTS (CONTINUED)

PLANT CODE	SPEC. NO.	802- B.S.P.	VOLTAGE	MAX. AMP CAPACITY	APPLICATION
806H[2]	J86815	904-155	84-88	0.5	20 HZ ringing and precise tone for No. 1 ESS Office
807B[1]	J86816	904-160	-	-	Wide area dialing systems
807D	J86829	904-162	-	-	Touch Tone supply for crossbar and SXS offices
807E[2]	J86839	904-163	-	-	Tone supply for No. 1 TSPS offices
807F	J87813	904-164	-	-	Touch-Tone supply for panel, crossbar and SXS offices
807G[2]	J87814	904-165	-	-	Precise busy tone supply for SXS and crossbar offices
808A[2]	J86834	906-150	84-88	6.0	20 HZ ringing and precise tone supply for No. 1 ESS offices
812A[2]	J87801	905-155	84-88	1.5	
831A[1]	J87803	910-150	84-88	0.5	20 HZ ringing and tone supply for 4-wire No. 1 ESS office
841A[2]	J87804	915-150	84-88	0.5	20 HZ ringing and tone supply for No. 2 ESS office
852A[2]	J87807	921-150	84-88	1.5	20 HZ ringing and tone supply for No. 5 Crossbar offices
853A[2]	J87809	922-150	84-88	6.0	
861A[2]	J87812	930-155	84-88	0.5	20 HZ ringing and tone supply for No. 1, 350 and 355 SXS offices

Figure 10.4 (cont.) - Standard Ringing Plants

RINGING PLANTS (CONTINUED)

PLANT CODE	SPEC. NO.	802- B.S.P.	VOLTAGE	MAX. AMP CAPACITY	APPLICATION
862A[2]	J87810	931-150	84-88	1.5	20 HZ ringing and tone supply for No. 1, 350 and 355 SXS offices
863A[2]	J86881	932-150	84-88	6.0	
872A	J87808	939-150	± 105	1.25	PBX feeder supplies
873A	J86855	940-150	± 105	5.0	

Notes: 1. Utilizes solid state generator, machine interrupter.

2. Utilizes solid state generator and interrupter.

Figure 10.4 (cont.) - Standard Ringing Plants supply leads. On T.C.E. jobs, the Telephone Company engineer must determine that all tones required are available on existing ringing fuse panels. This determination is especially important when a new type of equipment (as a group alerting system) is being added in the office for the first time. Criteria for ringing conductor sizing and fusing are outlined in EIM 6629, available from Western Electric.

10.7 Ringing Demand Meter

The 20 HZ output of a ringing machine fluctuates so rapidly that a statistical method must be employed in determining the actual 20 HZ ringing current drain. The procedures employed in doing so are outlined in BSP 802-029-160 which covers use of the ringing demand meter.

Every ringing plant should be equipped with connectors for the ringing demand meter; it is the responsibility of the Telephone Company equipment engineer to specify their installation.

10.8 Criteria for Selecting and Sizing a Ringing Plant

An existing ringing plant should be capable of handling the projected ringing load expected at the end of the power engineering period for the job under consideration. Detailed instructions for sizing a ringing machine are covered in BSP 802-004-152 and section 10.9 of this practice.

The following procedures should be used in selecting a new ringing plant (including replacement of an existing plant):

1. From the information included in figure 10.4 and the referenced BSP's, select a ringing plant which satisfies the basic criteria: type office, tones required; solid state operation.
2. Select the size plant that will handle ringing requirements for the life of the equipment entity it will serve.

The ringing demand of the equipment associated with the initial installation of the ringing plant may be used in estimating the ultimate size plant required. As an example, using procedures outlined in section 10.9, it has been determined that an initial installation of one unit of No. 1 ESS will require 700 ma (milliamps) of ringing current. It is planned to ultimately install three units in the building. Therefore, the ultimate drain can be projected at 2.1 amps (3 X 700 ma). In this case, to avoid the expensive replacement of the ringing plant, a 6.0 rather than 1.5 amp plant would be installed.

10.9 Ringing Calculations, BSP 802-004-152

The calculations for sizing ringing plants outlined in BSP 802-004-152 are based on the assumption that adequate tone capacity will be available if the ringing generator is adequate to handle ringing current demand.

BSP 802-004-152 outlines thirteen steps to be followed in determining the total ringing current drain. This section of the practice is designed to supplement information in BSP 802-004-152 and will point out sources for the required information.

Step (1) - No. of Busy-hour Terminating Calls

Busy-hour terminating call peg count data is not gathered for SXS and No. 5 crossbar offices. Therefore, an estimate using available traffic data, must be made of the number of calls requiring specific types of ringing (Ring 1, Ring 2, coded ring). The following procedures may be used in making those estimates:

SXS Office:

Figure 10.5 is a typical SXS grouping sheet outlining requirements for trunking from fifth selectors. The encircled CCS figures for each type of ringing equipment can be totaled and, using an average of 3.0 CCS per call, the total busy-hour (BH) calls can be estimated. Using figure 10.5, the following can be developed:

	CCS	
Level	1, 2 & 4 party full selective 1-ring	5 code, 10 party
1-3	294	---
4-6	---	216
7-0	366	---
Total	660	216

Assuming 3.0 CCS/call.

$$\text{Total BH 1-ring calls} = \frac{660\ \text{CCS}}{3.0\ \text{CCS/call}} = 220\ \text{calls}$$

$$\text{Total BH coded ring calls} = \frac{216\ \text{CCS}}{3.0\ \text{CCS/call}} = 72\ \text{calls}$$

If 8-party, semi-selective, rather than 5-code ringing were required, the grouping sheets would reflect this (The Traffic Order forecast of lines and terminals or 16A report should be checked to see if there are any multi-party customers actually working in these boards). The requirement for Ring 1 and Ring 2 would be determined assuming that half the calls would be derived from each. If four party, semi-selective (rather than full selective) ringing was being utilized, an estimate of the number of calls terminating in 4-party lines would have to be made.

No. 5 Crossbar Office:

No. 5 crossbar traffic orders contain the two pages shown in figures 10.6 and 10.7. To compute the BH calls by types of ring, the average terminating CCS/MT must first be determined. Using figures 10.6 and 10.7, the

T.O. 72-S-14
Page N-6
2-16-72

426 Fifth — SELECTOR MULTIPLE ARRANGEMENT- SEL. BANKS — 4-75 PERIOD

LEVEL	TO	EQUIV. 100" CALLS	SUB-GRPS.	SELECTORS PER SUB-GROUP L	T			CAP TBL			TRUNKS PER SUB-GRP.	TOTAL	TERMINATE
				3000 GROUP									
											Sel.	Bks	
			Loc.	5th Sel. (3 wire)				(L)			43	50	
			Toll	5th Sel. (4 wire)				(T)			10*	10*	
0	Rotary (1)	L 125	1	43	10			20			10	10	Comb. Rotary
		T 25											1 RING
		(150)			ONE RING								
		(166)											
9	Reg. (1)	L&T (72)	1	43	10			20			7	7	Comb. Conn
		(97)											1 Ring
8	Reg. (1)	L&T (72)	1	43	10			20			6	6	Comb. Conn.
		(76)											1 Ring
7	Reg. (1)	L&T (72)	1	43	10			20			7	7	Comb. Conn.
		(97)											1 Ring
6	To 4 Rural (3)	L&T (72)	1	43	10			20			7	7	Comb. Conn.
		(97)											
						5 CODE, 10 PARTY							10 Pty
													Div. Ring
3	Rotary (1)	L 125	1	43	10			20			10	10	Comb. Rot.
		T 25											Hth 1 Ring
		(150)											
		(166)											
						ONE RING							
2	& 1 Reg. (2)	(72)	1	43	10			20			7	7	Comb. Conn.
		(97)											1 Ring
			*	Present Equipment									

Figure 10.5 - CCS Determination For SXS Office

T.O. 72-S-19
Page 1
3-24-72

FORECAST OF LINES AND MAIN TELEPHONES

AS OF 4-74

FORECAST 2-1-72

33, 648

	Terms	Lines
FR 1	13190	13190
FR 2	215	126
FB 1	876	876
MB 1	40	40
CB	229	229
SUB-4	21	7
PBX-F	143	143
-M	4	4
ODT	-	5
TOTAL	14718	14620
CONS. NO.	579	
TOUCH-TONE	4014	

TOTAL MAIN TELEPHONES

Figure 10.6 - No. 5 Crossbar Traffic Order

T.O. 72-S-19
Page 5
3-23-72

DISTRIBUTION OF TERMINATING TRAFFIC

As of 4-74

From:	% of LLF Total Usage	CCS OBH	CCS GBH	TRUNKS REQUIRED	TRUNKS PROVIDED
Inter Ofc - Total	41.36	21246	-		
- 22			3410	116	124
- 34,692			1104	44	47
- 43			900	39	43
- 53			3901	140	150
- 73			1510	59	65
- 82			1375	53	58
- 92,624,627,628			1829	70	70
- 622			270	15	16
- 623			193	12	13
- 624,628 (a)				18	18
- 626-1			195	12	13
- 633,635 (a)			765	34	34
- 649			271	15	17
- 655,651 (a)			1232	50	55
- 658			720	31	34
- 661,667			1880	69	69
- 674,677-9 (a)			800	35	38
- 684,688 (a)			570	27	29
- 694,697			300	16	18
- 695			127	10	11
- 698 (a)			221	14	15
- 696 (a)			1144	47	52
- 64 Tandem (648&649)			7014	362	362
Intra Ofc - FR	13.76	7068	7359		
- MR	.01	5	54		
- CB	.40	206	343		
- MR to PBX	.01	5	20		
Toll SW - 4A (a)	.87	446	1535		83
- Opr NC (a)	.04	21	295		28*
CB	.01	5	80		13*
DSA - Opr (a)	.01	5	10	9	
- Verif (a)	.01	5	10	5	
Total	56.48	29012			

29012 → TOTAL TERMINATING CCS DURING OFFICE BUSY HOUR

(a) Include Traffic to 648 & 649

Figure 10.7 - No. 5 Crossbar Traffic Order

total terminating BH CCS and main telephones are 29,012 and 14,718 respectively. To compute, BH terminating CCS/MT =

$$\frac{\text{BH terminating CCS}}{\text{MT}} = \frac{29{,}012\ \text{CCS}}{14{,}718\ \text{MT}} = 1.97\ \text{CCS/MT}$$

This figure would then be multiplied times the total MT for each type of ring call to determine the total calls. In this office, only 1-ring calls are required (no coded ringing required, see figure 10.6); the total BH terminating calls (assuming 3.0 CCS/call) can be computed simply by dividing the total terminating CCS by the average CCS/call or,

$$\frac{29{,}012\ \text{Term CCS}}{3.0\ \text{CCS/call}} = 9671\ \text{calls}$$

Step (2) - (A + D)/3600

The "A" and "D" factors should be taken from the tables included on pages 2 and 3 of BSP 802-004-152.

Step (3) - Average No. of Simultaneous Busy-hour Calls

Multiply the results of (1) by step (2) for each type of ring.

Step (4) - Brush Factor

To determine the brush factor, the interrupter timing information shown in figure 1 of BSP 802-004-152 must be determined for the plant being sized. This information is shown on the SD drawing for the interrupter circuit.

Step (5) - Average No. of Simultaneous Busy-hour Calls

Multiply the results of step (3) by step (4) for each type of ring.

Step (6) - Average Ringing Drain Per Call

Figures to be used in the appropriate formula should be obtained as follows:

- R, ringer drain: for the purpose of these calculations it can be assumed that all sets utilize high impedance ringers.
- P, percent of party-line fill: the present party line fill is shown on the demand and facility chart for the office. It can be assumed that no significant changes will occur when considering some future date. Be sure to convert the demand and facility chart figure to a percentage figure.
- E, percent extension stations: present figures can be obtained from the 16A report filed in Plant Extension. It can be assumed that no significant changes will occur when considering some future date.
- A, average ringing drain per call: be sure this is expressed in milliamperes.

Steps (7) thru (12)

Complete each of these calculations in accordance with the instructions given in BSP 802-004-152.

Step (13)

Use the nomogram included as figure 10.8 for determining the size of ringing generator required.

10.10 Ringing Machine Data Entries, SWX-XXXX-550-G Drawing

Figure 10.9 contains that portion of the SWX-XXXX-550-G drawing which is applicable to ringing machines. Section VII, part A should be used to record the type plant (as 803C, 804C, J86212T shelf, etc.) and the capacity of that plant for both the present and power engineering period dates.

Section VII, part B should be used to record the demand on the ringing machine as of the date shown. Once an initial load determination is made for the office and entered on the SWX-XXXX-550-G drawing, it will usually not be necessary to update this information each time the drawing is updated. This set of calculations should be made, however, whenever a new ringing plant is being installed in order to insure proper sizing of the plant.

Section VII, part C should be used to reflect whether or not an office is equipped with connectors for a ringing demand meter and, if applicable, the results of the last load study. The load study need not be made each busy season but should be scheduled by the Telephone Company engineering and Plant representatives as the need arises.

10.11 Engineering Responsibilities

The Telephone Company equipment engineer is responsible for the following ringing machine determinations:

- Size, type, location and questionnaire information (E1896) for all new ringing plants.
- When replacing an existing plant, specifying whether Type A or D ringing is required.
- Specifying installation and use of the ringing demand meter connectors.
- Completion of section VII of the SWX-XXXX-550-G drawing.
- On F&I jobs, insuring that all required tones are available in the office.

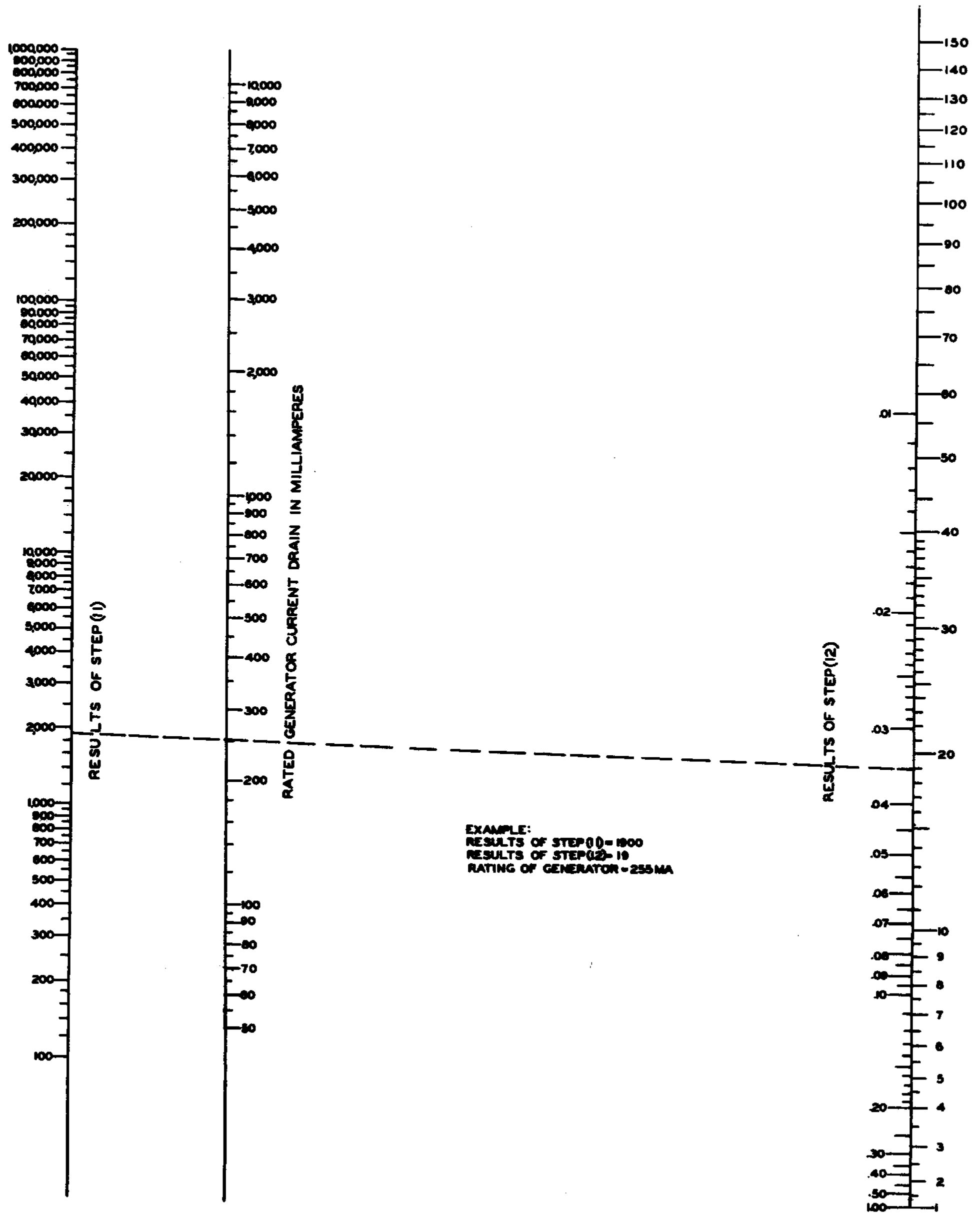


Figure 10.8 - Nomogram for Ringing Drain Calculation

VII RINGING MACHINE DATA

	PRESENT	PWR. ENGR. PER
A TYPE PLANT	862 A	862 A
CAPACITY	1.5	1.5

B PROJECTED LOAD AS OF 9-75 (DATE) (PER BSP 802-004-152)

STEP NO. BSP 802-004-152 / TYPE OF RING:	ALL	RING I	CODE		
STEP (1)	X	1220	172		
STEP (2)	X	.0045	.0078		
STEP (3)	X	5.5	1.34		
STEP (4)	X	0.33	1.0		
STEP (5)	X	1.82	1.34		
STEP (6)	X	18	37.5		
STEP (7)	X	32.8	50.3		
STEP (8)	X	5900	1890		
STEP (9)	83.1				
STEP (10)	6910				
STEP (11)	7790				
STEP (12)	.89				
STEP (13)-GENERATOR SIZE, AMPS	.33				

C. THIS OFFICE IS EQUIPPED WITH CONNECTORS FOR A RINGING DEMAND METER. YES X NO ____
LAST READING: DATE 9-25-72 ; RESULTS: 1.5 AMPS - FULL SCALE; 100%-0; 75%-0; 50%-0

Figure 10.9 - Ringing Machine Entries, SWX-XXXX-550-G Drawing

PART B - SECTION 11.0
GROUNDING SYSTEMS

11.1 Purpose and Types of Grounding Systems

A ground is a conducting connection between an electrical circuit, component, equipment or housing of the equipment and earth or some conducting body which serves in place of earth. In a telephone office, ground is assumed to be the point of zero potential or voltage and is referred to as the central office ground.

A bond is a solid, low-resistance, metallic connection between two or more electrical components or their metal housings. The wire connecting two adjoining pipe supports at the top of the bays, the connection between a ground wire and each end of a conduit through which it runs and the straps across the flexible waveguide sections are examples of bonds.

A circuit or item of equipment is effectively grounded (via ground and bonds) when permanently connected to earth through a ground path of sufficient capacity to prevent a buildup of voltages which may result in circuit noise, undue hazard to personnel, or equipment damage.

Telephone offices have three grounding systems: (1) the AC service ground (neutral); (2) the protection or potential ground consisting of the equipment ground, framework ground, relay rack ground and the ring ground; and (3) the battery return ground.

These ground systems are designed to:

1. Eliminate electrical hazards by protecting personnel from faults which develop in the system (by providing electrical paths of sufficient capacity to permit protective devices, such as fuses or circuit breakers, to operate should a fault occur).
2. Provide protection against damage by lightning and from power fault currents.
3. Provide protection against corrosion by proper application of common grounding.
4. Minimize effects of noise.

Procedures for proper grounding are contained in BSP 802-001-180 (Protective Grounding Systems for Power Plants) and BSP 802-001-190. Included in these practices are references to drawings and practices covering grounding requirements for most types of telephone equipment.

11.2 Ground Electrodes

The ground electrode is that conductor (pipe, rod, plate, or cable) which is placed in the earth for the purpose of maintaining ground potential on conductors connected to it and dissipating to earth the current conducted to it. A metallic underground water piping system shall always be used as the principal grounding electrode when it is available. The water piping system shall be checked or verified with the water company to determine if the buried portion of the water pipe is a continuous metallic public water system. Where the water pipe is of nonmetallic material or is not continuous (i.e., equipped with insulating couplings at the water meter) a supplementary ground field is required. The water companies have been experiencing corrosion problems on their metallic water systems. In some areas there has been a definite trend toward the use of nonmetallic pipe and insulating couplings. While it is not a requirement to provide a supplementary ground field where the water system is determined adequate, it is highly recommended that this be considered during the initial construction period of a building. With the possibility existing that the water company may create at a later date one of the conditions which would make the water pipe inadequate, excessive expense may be encountered should it become necessary to add a supplementary ground field. Where assurance cannot be obtained that the pipe will remain as an effective ground electrode, a supplementary ground field should be provided.

As the principal grounding electrode, the water pipe shall be a continuous metallic underground public system, or a private system of buried metallic pipe or well casing. Where the private system is used, the metallic underground piping shall be bonded to the well casing and the combination of the buried portion of pipe and well casing shall not be less than 10 feet.

Preferable, all ground leads shall be attached to the water pipe system on the street side of the water meter; however, under either of the following conditions, all ground leads may be connected to building side of the water meter:

1. In some instances there may be insufficient exposed length of pipe on the street side of the basement installed water meter. The leads should be connected close to the meter.
2. In some buildings the water meter may be located outside, making the pipe on the street side of the meter inaccessible for connecting ground leads. Connect the leads at the point of entrance of the pipe into the building.

The water piping system shall be made electrically continuous by bonding across the meter, valves, or service unions which might be disconnected. This will insure electrical continuity where ground attachments are made to the pipe on the house side of the water meter. Special attention should be given to the water meter bond. No bond should be placed across the meter where the pipe on the street side of the meter is not Telephone Company owned without obtaining water company permission or where there may be an insulating coupling at the meter which should not be strapped. The supplementary ground field shall be connected to the interior water piping system as close to the meter as possible.

In structural steel buildings, all building columns shall be connected to a supplementary ground field. The conductivity of concrete surrounding the building columns cannot be relied upon for providing an adequate ground path. A driven rod shall be placed adjacent to each column footing. The rods and columns shall be interconnected by means of PVC insulated No. 2 gauge copper conductors and connected to the interior cold water systems. A typical arrangement for the supplementary ground field is shown in figure 11.1.

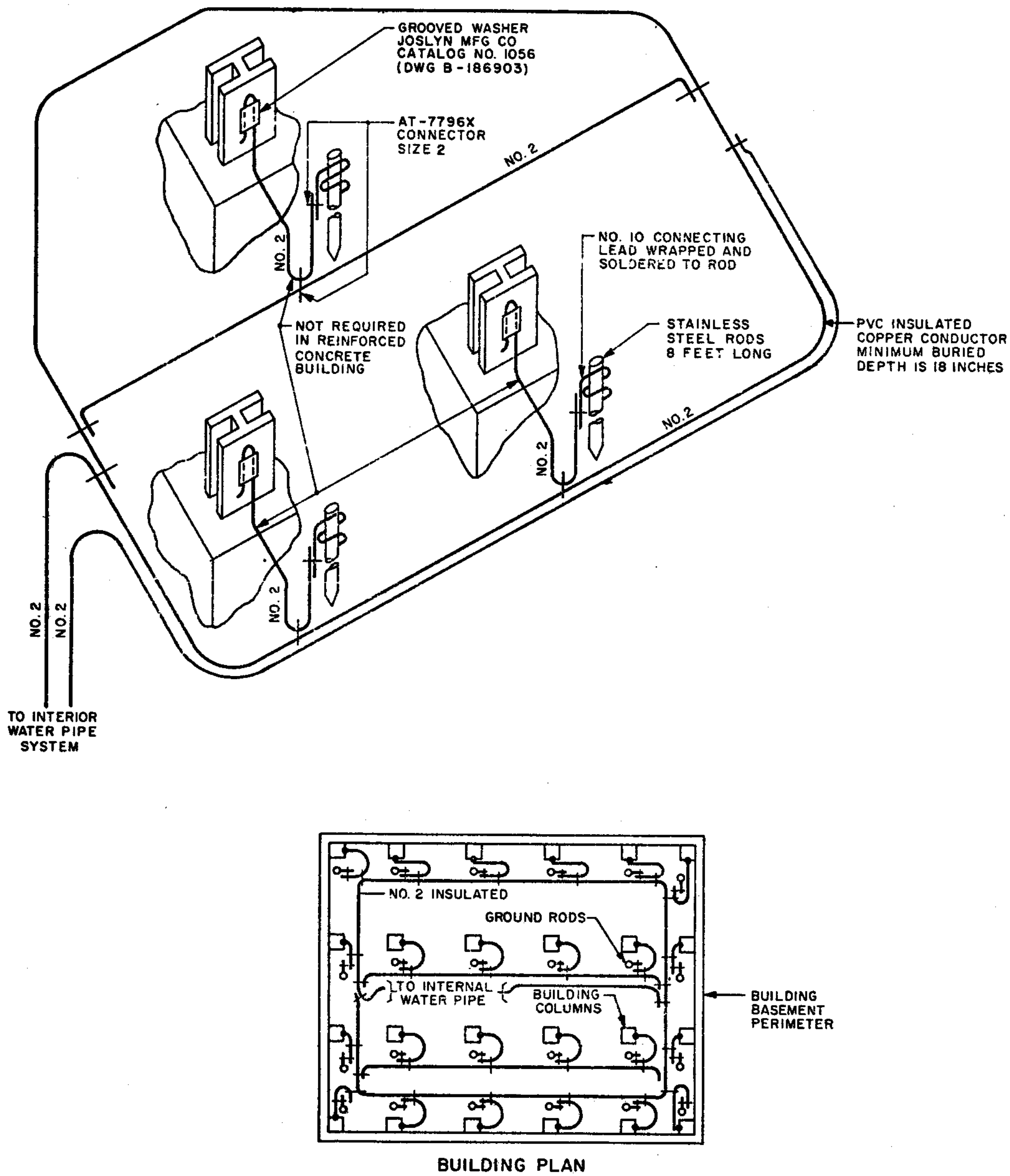


Figure 11.1 - Typical Supplementary Ground Field - Structural Steel And Reinforced Concrete

A driven rod ground field similar to the one described for a structural steel building shall be used for a building constructed of reinforced concrete. However, there shall not be a connection from the ground field to the columns since the continuity of reinforcing bars cannot be relied upon.

Made electrodes consist of a series of driven rods or pipes interconnected with copper conductors. Within the Bell System, copper clad rods have been principally used. In some small installations, such as TJ radio, community dial offices, etc., iron pipes interconnected with bare copper wire have been used. The philosophy in this latter case being that even with the possibility of corrosion of the iron pipes, the sizeable length of bare copper wire remaining in the earth was considered adequate. However, a copper wire counterpoise shall only be used where rods cannot be driven due to bedrock being less than 10 feet below the surface. There are benefits to be derived from supplementing the buried conductors with rods. Practices suggest the placing of the grounding conductors at a depth of about 18 inches below grade. There are many areas where frost penetrates the earth to depths exceeding 18 inches in which case a substantial increase in earth resistivity occurs.

A supplementary ground field shall consist of driven rods buried deep in the excavation (for buildings with basements). For small buildings (no basement), such as unattended central offices, 355A, SXS, microwave and radio stations, rods shall be driven outside of the building, 2 feet from any wall. Rods will be placed at the corners of the building, with intermediate rods between the corner rods spaced evenly and with the distance between rods not to exceed 10 feet. A ring counterpoise of No. 2 gauge tinned solid copper conductor shall be run around the exterior perimeter of the building interconnecting all the rods (see figure 11.2). All ground fields shall be bonded to the internal cold water piping system of the building by at least two conductors. In locations where water systems are not available, the driven ground field will be the sole grounding arrangement.

All grounding systems (i.e.; power company ground field, telephone company ground field), if they are different, shall be bonded together to limit potential differences between grounds and their associated wiring systems. The maintenance of a common reference ground is a goal of prime importance.

11.3 Principal Equipment Room Ground Bar

In the grounding systems found in older telephone offices, a ground bus bar was mounted on the main or combined distributing frame and was normally tied to the water pipe system on the street side of the water meter. All ground requirements were fed directly from this ground bar or from bays, framework, relay racks,groundbars, etc. fed from the ground bar.

With the issuance of Issue 9 of BSP 802-001-180 in 1967, use of a supplementary ground field was proposed and new grounding procedures for single- and multi-storied buildings were outlined.

All buildings with two or more floors, basement included, above or below ground, shall have at least one vertical ground riser. On each equipment floor a bus bar representing the principal equipment room ground bar shall be provided and connected to the riser. In the basement the riser shall be connected

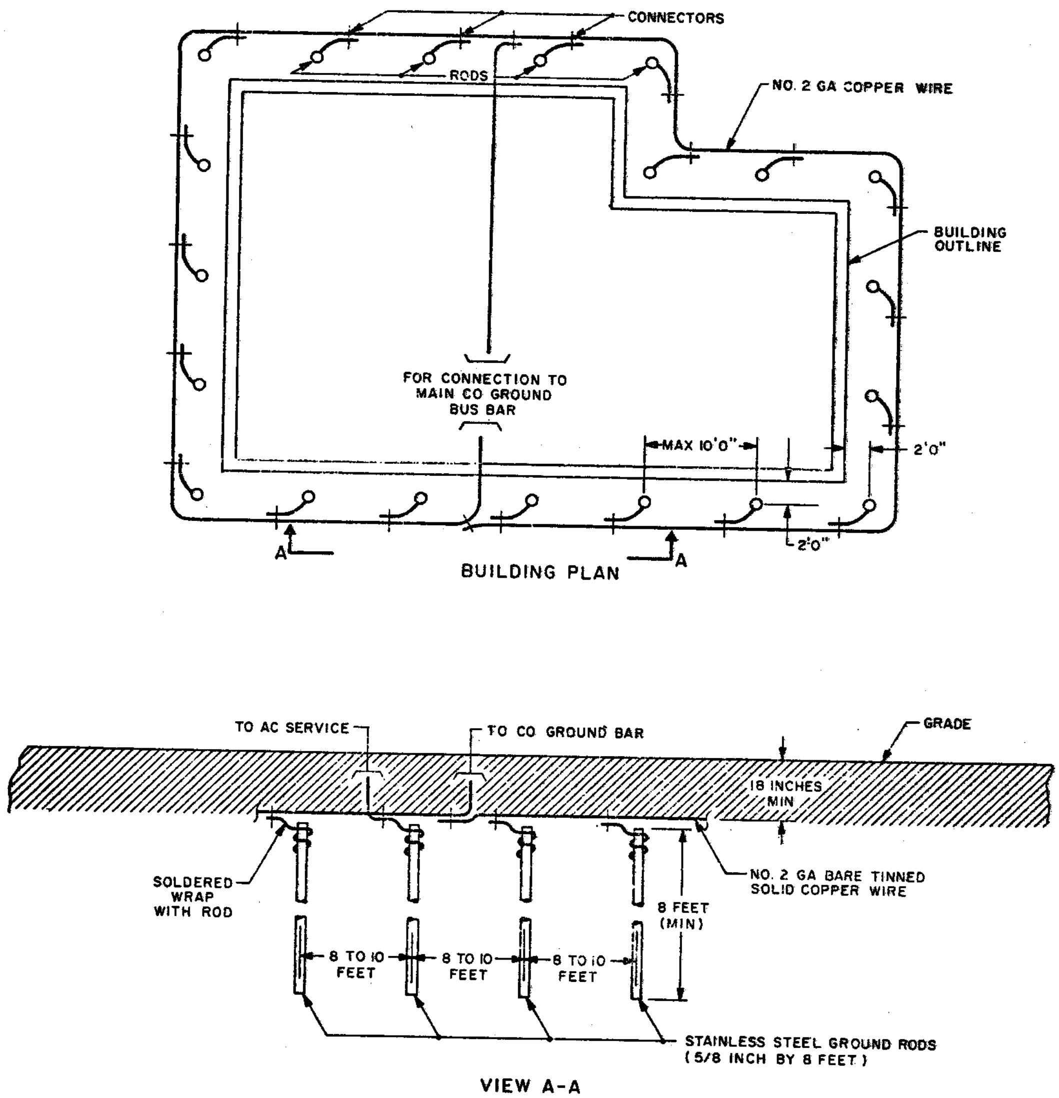


Figure 11.2 - Typical Supplementary Ground Field, Building Without a Basement

to the water pipe. Effectively the riser will bring the water pipe (central office or CO ground) to the equipment floor. SD-81899-01 covers the detailed instructions for adding the vertical ground riser and a horizontal grounding network to new and existing offices. By establishing a principal ground bar on each equipment floor, the practice of running conductors between floors looking for a suitable ground will be eliminated. On each equipment floor a horizontal ground equalizer shall connect all equipment on the floor to the appropriate floor CO ground bus bar. The equalizer cable will supplement any standard grounding arrangement in an office. All grounding arrangements for particular dc distribution systems (i.e., microwave, dial, ESS, etc.) and covered by SD drawings shall be maintained. The equalizer cable will interconnect the various distribution systems. Where standard circuits call for a connection to the water pipe or CO ground, the appropriate floor ground bus bar shall be utilized.

In complete toll areas or for toll line-ups in non-toll areas where no standard SDs are available, a horizontal ground network shall be provided bonding together all battery distributing fuseboard (BDFB) ground bars, fuse bay ground bars, relay rack ground bars, frameworks, and duct-type bays. This network will insure the provision of adequate bonding and grounding of all equipment on that particular floor and when applied in conjunction with the vertical ground cable will assure a positive connection to the ground source by the most direct path possible. The intent of the equalizer is to reduce potential differences between ground bars, frameworks, and superstructures in a telephone office. Cable racks, superstructure frameworks, etc. should not carry currents to the BDFB or to the power room.

This supplementary tree grounding arrangement, with branches connecting all bay lineups and frames to a trunk which is connected to the ground electrode, will effectively bond together all bays through a single path. With the ideal tree there will be an equalization of potential differences between ground bars and framework grounds on each floor and a direct path for spurious noise currents to earth potential will be provided. The ideal tree would be connected to the building steel only at the waterpipe, however, this would create a safety hazard. For example, if the water pipe is at one corner of a large building, a lightning stroke at the opposite corner could raise the potential of the building framework by thousands of volts relative to the equipment bays. By connecting the CO bus bars on each floor to building steel, the hazard is reduced.

The principal ground lead shall not be enclosed in a metallic enclosure. Previous practice required that when the main ground lead was so enclosed, both ends of the enclosure were required to be bonded to the main ground lead. Investigations of many offices have indicated that this bonding requirement had been omitted. The bonding of the metallic conduit was important since this prevented an increase in inductance of the ground lead by the metallic material of the conduit and also avoided possible arcing between the lead and conduit. The new requirements for nonmetallic enclosures for ground leads eliminates the need for bonding and therefore eliminates the hazards associated with improper bonding. The principal equipment room ground lead should be run exposed--not buried on a cable rack nor enclosed in metallic conduit. Where a mechanical guard for the main ground lead is required, such as when this lead is run outside of the building, the lead shall be run in nonmetallic electrical conduit. All of the conductors associated with the horizontal and vertical grounding system shall be supported below the cable racks.

In single-storied buildings it is recommended that a principal central office ground bar be established. Where a CO ground bar is not installed, all equipment requiring a CO ground connection (i.e., power plants, distributing frames) must be terminated on the water pipe or other ground electrode. The application of a ground bar provides an accessible location for terminating the required ground leads. In offices similar to a 355A community dial office or a small step-by-step No. 1 office, where the addition of toll bays does not meet the requirements for a horizontal ground equalizer, the principal central office ground bar may be the ground bus bar on the main distributing frame. The main distributing frame shall be bonded to the ground electrode. The horizontal ground equalizer may or may not be required in a single floor building. The ground equalizer is required for an ultimate of four or more toll equipment lineups (with a fuse bay included in one of the lineups) and shall not be installed for 1, 2, or 3 lineups.

11.4 Battery Return Ground

Unless otherwise specified on standard power plant circuit drawings, the main power plant ground lead shall be run from a point on the discharge ground bus bar to the principal CO ground bus bar located on the same floor as the power room or to the central office ground electrode. The size of the power plant ground lead as specified on standard drawings (usually a No. 0 lead) is adequate in offices which do not use the new horizontal and vertical grounding arrangement. With the installation of the new grounding concept, the size of the power plant ground lead shall be increased as indicated in Table C of BSP 802-001-180. Dedicated power plants for electronic type offices have a special grounding requirement. See part B, section 11.7.

The discharge ground arrangements for a particular office will be shown on the Western Electric wiring lists and block schematics for that office. The various components of the discharge system will be sized to handle the sum of the individual circuit ground requirements. The criteria for sizing ground leads are the same as those outlined for battery leads in part B, section 6.12.

11.5 AC Service Ground

The AC service ground is provided as a reference point for the AC power system. For the incoming AC service it is properly placed at the service entrance switch or circuit breaker in accordance with local or national electrical codes. With the application of the vertical ground riser and floor bus bars as described on SD-81899-01, any secondary AC systems, such as transformers or engine-alternators, shall be bonded to the ground bus bar of the floor on which they are located. The AC service ground is also referred to in many publications as the system ground.

In AC systems the current carrying conductor of a distribution or wiring system which is connected to ground is referred to as the neutral conductor. This is the grounded lead of a system as compared to the grounding lead which does not normally carry current but references the system with the ground electrode.

Under no circumstance shall a neutral conductor again be grounded after it has been grounded once at the service entrance. This requirement is necessary to avoid 60-HZ return current passing through framework, conduit, etc., thereby causing noise in susceptive circuits.

11.6 Protection and Potential Ground

As mentioned previously there are four types of protection ground: equipment, framework, relay rack and ring.

Equipment Ground

All electrical equipment enclosures and conductor enclosures shall be grounded. This is equipment ground. An equipment ground consists of a metallic connection to ground of noncurrent carrying metal parts of the wiring system or apparatus connected to the system. This includes all metal raceways, outlet boxes, cabinets, switch boxes, motor frames, transformer cases and metallic enclosures for all electrical equipment. The primary objective of equipment grounding is greater safety and assurance of clearing a fault.

A ground fault occurs when contact is made between a live conductor and a point at or near ground potential. This occurrence is most commonly caused by the failure of insulation. A hazard to personnel exists at the time the ground fault occurs. Any fault will cause a ground current to flow from the fault to the source of power. There must be an effective low impedance ground path established to insure a low voltage and high current result. Forcing the current to flow through a high-impedance grounding connection may create a dangerous potential difference. The high current is needed so that the protective over current devices will function to remove the line from service in minimum time.

In the past it was generally believed that adequate equipment grounding could be obtained by grounding the electrical apparatus (fixed cabinets, motors, rectifiers, etc.) to steel building structures or by having the equipment served by grounded metallic conductor enclosures. Conduits and raceways carrying AC service were assumed to be adequately grounded by their mechanical connections to house service cabinets and incidentally grounded by being clamped to framing bars, superstructures, cables, racks, etc. In many instances the frequent bolting of conduit to various racks and pieces of equipment throughout the office does not necessarily mean that an adequate ground fault path has been provided and all shock hazard eliminated. The use of nonconductive finishes in many cases decreases the dependance upon grounding through auxiliary framing and cable rack structure. The external bonding of conduits to various grounds may also prove to be ineffective at times.

Under the new procedures outlined in BSP 802-001-180, to insure an adequate ground fault return path, a separate grounding conductor enclosed in a metallic raceway with the phase conductors shall be provided for circuits with protective devices rated above 20A. For circuits with protective devices rated 20A or less, a separate grounding lead is not required when conductors are enclosed in metallic raceways. The fault current path will rely entirely on the metallic enclosure of the leads. Where the metallic enclosure may be subjected to corrosion (i.e., run outdoors or buried) or where metallic raceway is not used, the grounding conductor shall be furnished in all cases.

The separate grounding conductor arrangement is known as the green wire (see figure 11.3) concept since this grounding conductor for AC operated equipment is identified with a green color code (unless bare). This distinguishes this lead from the current carrying ground conductors (neutrals) which are white or gray. Present policy calls for only new buildings and additions to be equipped with the green-wire system. Old telephone offices will not be retrofitted at this time.

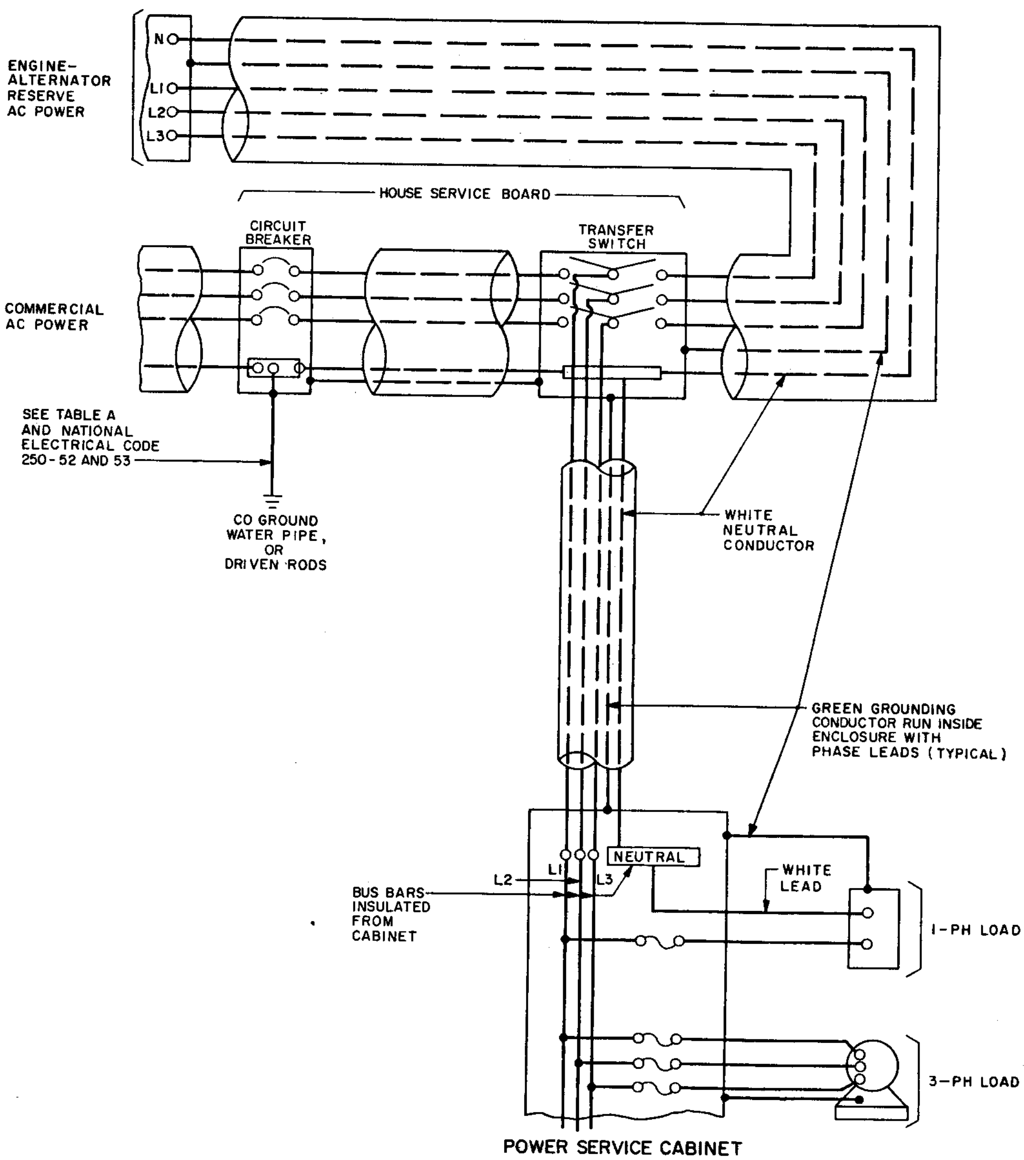
The green wire shall be secured to the equipment enclosure at the source of power and at the apparatus being served by the AC supply. Grounding conductors shall be insulated and shall be large enough to carry the ground fault current safely.

The current return conductors (neutrals) which are grounded at the source shall not be used for equipment grounding. Separate conductors (white or gray for neutrals, green or bare for grounding conductors) shall be used for these functions. The common grounding lead must be connected on the supply side of the service disconnect unit. The AC distributing cabinets shall be equipped with a neutral bar (which is insulated from the enclosure) and a grounding bar (which is bonded to the enclosure). The grounding bar provides a means for terminating the green wires to the cabinet. When the grounding bar is not provided, the green grounding conductors may be terminated in a suitable lug or punching secured to the cabinet.

Equipment grounding is required whether the system is grounded or not. Ungrounded systems may operate for extended periods with a single phase fault to ground. During such periods a contact between another phase conductor and an ungrounded metallic enclosure raises the enclosure to full-line potential above ground. Failure to provide a suitable connection between enclosures and ground presents a serious hazard to personnel.

Certain procedures must be followed in grounding and bonding conductors:

Bus duct - Frames and metallic enclosures of equipment to which AC power is supplied from bus duct shall be grounded by means of a green wire enclosed with the phase leads, if the leads are protected by devices rated larger than 20A. To provide for the grounding connection, a four-conductor bus with four conductor plug-ins may be used for a three-phase, three-wire AC distribution system. In this case, the fourth conductor in the bus is used as a grounding conductor and the ground bus in the bus duct is then connected to the power source enclosure. A green ground wire run with the phase leads in the equipment cable is then connected to the equipment case or



NOTE 1: ALL CONDUITS ARE CONTINUOUS TERMINATING AT THE ENCLOSURES.

Figure 11.3 - Typical Equipment Grounding Arrangement Utilizing the Green Wire

frame at one end and to the blade of the plug which connects to the ground bus at the other. A five-conductor wire bus duct must be used in a three-phase, four-wire AC distribution system to permit using the fifth conductor as the grounding conductor.

Conduit - The addition of the green-wire equipment grounding conductor to AC circuits run in metallic enclosures does not lessen the requirements for conductor enclosure continuity, since part of the total ground fault current will flow through the enclosure. High impedance at conduit joints and connections may cause arcing and heating of sufficient intensity to ignite nearby combustible material or explosive gases if present. Any conductor enclosing shell, such as metal conduit, wireways, bus ducts, etc., confines the electric and magnetic effects to the interior of the raceway. The electrical continuity of a conduit shall continue to be maintained by any one of the following means:

(a) Threaded fittings with joints made up wrench tight where threaded rigid conduit is used.

(b) Threadless fittings made up tight.

(c) A metal bushing inside and a locknut, outside of metal boxes and cabinets when threaded conduit is used. If the outside locknut is inaccessible for tightening after installation, an additional locknut inside should be used. If the bushing is composed entirely of insulating material, use locknuts inside and outside.

(d) Other devices listed for the purpose by Underwriters Laboratories, Incorporated.

Armored Cable - To insure an adequate equipment ground system the Underwriters Laboratories requires that the cable armor (equipment ground return circuit) have a maximum resistance of 5 ohms per 100 feet. To meet this requirement most manufacturers of armored cable use a bonding strip. When armored cable is used for shielding ring and tone leads or telegraph leads, the armored cable must be connected to ground at both ends of the cable. Groups of armored cable may be bonded together with a strap and grounded with a single lead.

Shielded Cable - The elimination of noise from various systems can be greatly improved by adequate grounding of shielded wire and cables. Schematics indicate the critical leads and noise producing leads which are required to be shielded. The purpose of the shield on shielded wiring and of the metallic sheath over cable pairs, is to reduce the inductive exposure from external electric and magnetic fields or to prevent noise on leads from disturbing other equipment. Cable shielding is only effective when the shield is electrically continuous between grounding points. When shielded wire and cable are spliced, the electrical continuity of the shield must be maintained. An investigation of the optimum method of grounding shields which are intended primarily for shielding against electrostatic and electromagnetic interference is presently underway by Bell Laboratories. Until final recommendations are available, all such shields should be grounded as specified in the system drawing.

Other Leads - Conduits carrying circuits supplied by telephone or telegraph batteries, generators or rectifiers shall be grounded. The green wire is not required for such applications. Where conduits are not continuous, the free end (or ends) of the conduit should be connected to ground leads which are tied to the central office ground system.

Framework and Relay Rack Ground

A conductor that serves the purpose of placing the equipment framework at reference ground is known as a framework ground. A relay rack ground is a conductor which functions as a combination DC return and framework or equipment ground.

Frames of equipment were considered grounded when served by grounded conduits. Frames of equipment not connected to commercial power or grounded conduits were also considered grounded by being clamped to grounded racks, frames, or steel framework of the building. This is known as incidental grounding. Equipment requiring a protection ground should have a designed metallic ground path of either cable or bus bar. With the new horizontal grounding equalizer, all equipment frames will be grounded with a direct metallic connection of either cable or bus bar. Equipment not specifically required to be grounded, such as battery stands, machine tables and metal cabinets containing apparatus not connected to power service, shall be grounded if grounding is called for in other practices or specifications.

Relay rack bays require a framework ground. Where the equipment design requires a battery return current utilizing relay rack ground bars, the ground bar on the bay then becomes a combination framework and circuit ground, the framework ground may be provided by adding a ground bar (to be compatible with adjacent relay racks equipped with ground bars) or with a No. 6 conductor. The No. 6 framework ground lead is required when the relay rack bay is isolated from other bays or where the bay layout is such that it will be undesirable to add the ground bar. The terminal lug for the No. 6 lead shall be located on the inner side of an upright. The No. 6 framework ground lead shall be bonded to the nearest relay rack ground bar which is connected to the grounding system.

Where a circuit ground is required in addition to the regular framework ground, a ground bar of sufficient capacity shall be provided. Generally, a 1 by ¼ inch ground bar is adequate for this purpose. The unit ground bars of adjacent bays are joined together. Where ground bars are discontinuous due to a gap in the lineup, the bars shall be bonded with a 350,000 CM cable. At the head end of the lineup a 350,000 CM cable shall be connected between the ground bus bar and the main aisle ground equalizer when provided. Additional details regarding framework and relay rack ground are contained in BSP 802-001-180.

Ring Ground

The ring ground is the grounding arrangement used in radio systems to keep the equipment frames and building structures at an equipotential plane during a period of high fault current (lightning). See part B, section 11.8.

11.7 Electronic Offices

The ESS No. 1, 2 and TSPS No. 1 electronic offices are basically data machines consisting of thousands of transistors and other semiconductor components which use frames as a circuit ground plane. These systems cannot tolerate excessive transient voltages or noise which may be injected into a ground system. A special grounding system is required for these electronic offices which electrically, except at a single point, isolates these offices from the building steel, superstructures, etc., with no incidental grounding to equipment in other areas. The one point grounding technique is accomplished by using one ground location as the "ground window". All equipment within the electronic office complex sees this ground reference point and no other in the building. Extreme care must be exercised to insure that no foreign grounds come into contact with the electronic office equipment at any point other than at the window. This ground window should be on the same floor as the electronic equipment for maximum safety. Under no conditions shall any insulated electronic framework be more than one floor away from the ground window. Bonded to the ground windows are:

(a) The central office ground.

(b) The AC protective ground (all incoming conduits). Where the incoming conduits contain the green wire, the green wire must be bonded to the ground window before passing on into the electronic area.

(c) Connections to the power distributing frame ground bus bar.

(d) Any foreign grounds surrounding the electronic equipment, such as, lighting, cable racks, etc.

Of prime importance is the establishment of the single point ground. In an electronic type office all equipment frames, power distributing frames, remote power distributing frames and main distributing frames must be insulated from the building steel, underfloor ducts, buried piping, etc. to insure that no extraneous currents flow in the electronic equipment. To insure this isolation of equipment, anchor bolts used for securing the frames are insulated from the framework. The one point ground window is further established by the isolation of the DC battery from any power plant framework, cable rack, AC power conduits, etc. The power plant ground bus bars are insulated from the power plant framework. The power plant ground bus is then connected to the electronic office ground bus to permit both to be grounded via the same one-point ground. The framework, battery stands, etc., in the power room will be connected to the office ground similarily to the power equipment in any other type of office.

The ground window shall be connected to the floor CO ground bus bar which is part of the vertical grounding arrangement. In a structural steel building, the vertical riser will be connected to the building steel. In this manner potential differences will be avoided between the insulated electronic switching frames and the building, eliminating a potential hazard to personnel. The maximum combined length of the grounding conductor between the CO ground bus bar and the termination at the electronic equipment via the ground window shall not exceed 75 feet.

The main protector frame is not insulated from the building and may be adjacent to but isolated from the electronic equipment. It is essential that the protector frame be bonded to the ground window and to the CO ground bus bar on the appropriate floor.

Electronic type offices may be located on the same floor with other central office equipment. Cable racks, superstructure framing bars, conduits, etc. from other switchroom areas with uninsulated frames must be isolated from the electronic switching area by either an interruption (spacing) or by insulation at each point where they might touch the electronic area. The lighting associated with this area is also isolated from the electronic frames. The possibility of a difference in potential between the equipment insulated from the building and the uninsulated equipment exists. To minimize the possibility of a flashover, the surrounding equipment, racks framing, etc. shall be connected to the floor CO ground bar and the ground window.

At this time electronic type offices require dedicated power plants. The recommended location for the battery plant is on the same floor as or within one floor of the electronic equipment. This location minimizes potential differences between the insulated ground bar of the battery plant (which connects to the electronic equipment ground) and the battery plant cabinets which are connected to building steel. However, it is recognized that floor-loading and available space restrictions might make it impractical to satisfy this recommendation in existing buildings. When power plants are several floors away from the floor having electronic type frames, the hazard to personnel and power plant components from lightning surges increases. However, personnel are not normally in contact with the insulated ground bar of the plant and the hazard is reduced to a practical minimum.

Presently the Bell Laboratories is studying the feasibility of operating two electronic type systems (ESS and TSPS together or two or more ESS offices) from a common dedicated power plant. Assuming that such installations are compatible, the following requirements must be met:

(a) The various systems requiring single point ground shall be located no more than two floors apart (as ESS on sixth floor, TSPS on eighth floor) with the single-point ground window bonded to building steel on the middle floor. This arrangement establishes a ground no more than one floor away from any equipment using insulated frames.

(b) The ground window on the intermediate floor then becomes the last ground point common to external grounds for either system. The AC conduits for the systems are brought through the ground window. Conduit runs from the ground window into the electronic equipment must then be insulated from nonelectronic structures in order to maintain the one-point ground required and isolate the systems from any foreign ground currents.

(c) The ideal location for the common power plant would be on the same floor with the ground window thereby maintaining a one floor separation from the electronic system. The battery will be grounded to the one point ground window and shall not be grounded at the power plant.

11.8 Radio and Microwave Stations

Radio and microwave stations which are located in dedicated buildings have inner and outer station ground rings. The rings provide a ground source interconnecting the power service, power plant frameworks, all radio equipment bays, dehydrator, waveguides, air conditioning ducts, etc. The stations are susceptible to direct strokes of lightning due to the antenna and its supporting structure. To achieve an effective level of protection, equalization of voltage differences by frequent bonding of metallic components to the ring grounds must be provided. The inner ground ring is for protection purposes only and shall not be used as a battery return ground. The inner and outer ground rings provide multiple paths to earth and are adequate for the equipment for a typical floor plan. The SD drawings for the appropriate systems indicate the grounding requirements. BSP 876-210-100 covers in detail the requirements for lightning protection of radio and microwave relay stations including the location of protective devices.

When radio stations are installed in central offices and typical floor plan layouts are maintained, the standard inner ground ring shall be installed. The inner ring shall be connected to the floor CO ground bus bar associated wtih the vertical riser.

The antenna tower which is located on the building shall be provided with a ring interconnecting the tower legs. The tower ring shall be connected to the radio equipment ground ring or to the top floor CO ground bus bar. In addition, the tower base shoes shall be bonded to the vertical building steel. Waveguides associated with all radio towers shall be grounded before entering a building by bonding the waveguides to the metallic tower structure.

In reinforced concrete buildings, the tower base shoes shall be bonded to any vertical metallic riser. These risers may be a main AC service conduit, cold water pipe main for sprinkler system, elevator rails, etc. All vertical risers shall be bonded together in the basement and connected to the water pipe.

In many central offices the power plants which are either common to many systems or dedicated to the radio equipment are remote from the radio equipment room. In this situation no ring ground is required for the power plants and the normal grounding arrangement for the plant is adequate. The internal ring ground shall be placed around all of the radio equipment. The equipment bays shall be connected to the ring ground as required. Metal objects that are associated with the building structure, such as, air conditioning ducts, intake louvers, raceways, or vents in the vicinity of the radio equipment room shall also be bonded to the inner ring lead creating an equipotential plane. Vicinity is defined as an area where it is possible to simultaneously touch the metal objects and the radio frames.

11.9 Engineering Responsibilities

Principal Equipment Room Ground Bus

A. Single-story building

1. The architectural engineer is responsible for:

a. providing the supplementary ground field and connections to the water pipe (if available), central office ground bar (if no water pipe is available), and main AC service panel or cabinet;

b. providing necessary sleeves for running the ground connections;

c. strapping of water meter and/or valve.

2. The Telephone Company equipment engineer is responsible for:

a. specifying the location of the central office ground bar;

b. including the location of the central office ground bar on the SWX floor plan drawing;

c. verifying that the location of the central office ground bar has been included on the Western Electric floor plan drawing;

d. specifying use of a horizontal ground equalizer when required.

3. The Western Electric engineer is responsible for:

a. providing the central office ground bar in the location specified by the Telephone Company equipment engineer;

b. providing and sizing the leads connecting the ground bar to the water pipe (or ground field if no pipe is available) and the various equipment grounding systems, including any horizontal ground equalizers provided.

B. Multi-story building

1. The architectural engineer is responsible for:

a. providing the supplementary ground field and bonding the ground field to the building columns (in structural steel buildings);

b. connection of the supplementary ground field to the internal water pipe system and strapping of the meter and/or valve;

c. connection of the main AC house service cabinet to the internal water pipe system;

d. provision of the necessary sleeves for the tree ground system, if provided.

2. The Telephone Company equipment engineer is responsible for:

a. specifying use of the tree ground system (will always be used in new buildings or additions) and the number of vertical risers to be used;

b. specifying the location of the central office ground bar on each equipment floor;

c. specifying use of horizontal ground equalizers;

d. including the location of the vertical risers and central office ground bars on the SWX floor plans and verifying their inclusion on the appropriate Western Electric floor plan and block schematic drawings.

3. The Western Electric engineer is responsible for:

   a. providing the central office ground bars and cabling (including sizing) to the various equipment grounding systems;

   b. providing the vertical riser(s) and cabling to the central office ground bars and internal water pipe system;

   c. providing connecting cables between central office ground bars on every third floor when more than one riser is provided in a building.

<u>AC Service Ground or Neutral</u>

A. The architectural engineer is responsible for:

   1. connecting the neutral bus in the main AC panel or house service cabinet to the internal water pipe system or supplementary ground field (if no water pipe is available);

   2. providing the AC panel or house service cabinet equipment necessary for extending the neutral lead to the point of interconnect with Western Electric provided AC distribution equipment and cabling.

B. The Telephone Company equipment engineer is responsible for detailing in the Telephone Company specification the type AC service available at the main AC switchboard or at any secondary distribution points.

C. The Western Electric Company engineer is responsible for providing the supplementary AC distribution equipment and cabling equipped for the nuetral lead.

<u>Protection or Potential Ground</u>

A. Equipment ground, green-wire system.

   1. The Architectural engineer is responsible for:

      a. providing the neutral to ground bus bar link or strap to the main AC panel or house service cabinet;

      b. extending the green-wire ground to the point of interconnect with the Western-provided AC distribution system.

   2. The Telephone Company equipment engineer is responsible for:

      a. specifying use of the green-wire system. The green-wire system will be used in all new telephone equipment buildings and major additions. In existing buildings, the green-wire system will be specified on all new power plants (assuming the green-wire ground can be made available without replacing the AC distribution system) and additions of power service cabinets. Under present policy, an existing equipment building will not be retrofitted for the green-wire system since this usually requires complete replacement of the AC feeds (since the green-wire must be run inside the same enclosure that houses the phase and neutral leads).

b. outlining in the Telephone Company specification the requirements for the green-wire system.

3. The Western Electric engineer is responsible for providing and sizing a standard green-wire system in accordance with requirements outlined in the Telephone Company specification.

B. Other Protection Grounds.

The Western Electric engineer is responsible for sizing and providing all miscellaneous, non-circuit grounds.

PART C - SECTION 1.0
ESTIMATE REQUIREMENTS

1.1 General Requirements

The Telephone Company equipment engineer submitting an estimate request for new or major additions of switching or circuit equipment is responsible for including certain data concerning the associated power plant equipment. If power plant equipment is also being provided, the data must verify the need for that equipment; if no power plant equipment is being provided the data must verify the adequacy of the existing equipment. This data is included in the Vice President-Engineering and Chief Engineer's copies of the estimate request if power plant equipment is being provided. This data should still be completed if no power equipment is being added, but should only be included in the Chief Engineer's copy of the estimate request.

1.2 Power Plant Data Sheet

The "Power Plant Data" sheet, form SW-5073 (figure 1.1), is used to record pertinent information about the battery reserve, the power plant capacities and a summary of emergency engine capacities. This form should be completed for each plant in which power equipment is being changed and included in the Vice President-Engineering and Chief Engineer's copies of the appropriate estimate request. If multiple battery strings are involved and a battery age correction factor is used, a "Battery Capacity Age Correction Calculations for Multiple Strings" sheet, form SW-5074 (figure 1.2), should also be completed and included in the Chief Engineer's copy of the estimate request.

If the total installed charge capacity of a plant is being changed, a copy of the appropriate "Power Plant Data Sheet", form SW-5073, should be forwarded to the Architectural Engineer for a review of the adequacy of installed AC entrance and power company transformer equipment.

Separate power plant data sheets and age correction factor sheets are required for each power plant. Instructions for completing these forms are contained in part B, sections 7.3 and 7.4.

1.3 Emergency Power Data Sheet

The "Emergency Power Data" sheet, form SW-5075 (figure 1.3), is used to record the AC power (KW) required to operate the DC power plants, AC power plants, and essential building load during a commercial AC power failure. The size of the presently installed (if any) and proposed size of any new emergency engines is also recorded. This form should be completed and included in the Vice President-Engineering's and Chief Engineer's copies of all estimate requests adding or removing power plant equipment. The data from this form is also used to complete the last three lines of the "Power Plant Data" sheet, form SW-5073.

OFFICE ____________ CITY ____________ SPEC NO ____________

POWER PLANT DATA SHEET

DATE ____________
ESTIMATE REQUEST ____________

		______ VOLT PLANT	NOTE	PRESENT 19 ____	END OF PWR. ENGR. PERIOD 19 ____	ESTIMATED 19 ____
PER PLANT		TYPE OF PLANT				
		PLANT CAPACITY (AMPS)	1			
		TOTAL EQUIPPED CHARGING CAPACITY (AMPS)				
		CHARGING CAPACITY, LARGEST UNIT (AMPS)				
BATTERY RESERVE CALCULATIONS - PER PLANT	A	FINAL VOLTS PER CELL				
	B	BATTERY STRINGS - QUANTITY/LIST (YEAR INST)				
	C	BUSY HOUR PEAK DRAIN (AMPS)				
	D	VARIABLE DRAIN (AMPS)				
	E	VARIABLE DRAIN — 24 HOUR EQUIV. (AMPS)				
	F	CONSTANT DRAIN (AMPS)				
	G	POWER FAILURE DRAIN-ADDITIONAL (AMPS)				
	H	TOTAL BATTERY DISCHARGE DRAIN (AMPS)	2			
	I	AGE CORRECTION FACTOR - ALL STRINGS				
	J	TOTAL DRAIN CORRECTED FOR AGE (AMPS)				
	K	BATTERY RESERVE PROVIDED (HRS)				
	L	BATTERY RESERVE REQUIRED (HRS)				
PER PLANT		MAXIMUM DEMAND (KW) - THIS PLANT	3			
PER OFFICE		MAXIMUM DEMAND (KW) - TOTAL OFFICE				
		ENGINE-ALTERNATOR CAPACITY (KW)				

NOTES:
1. SHOW TOTAL CHARGE CAPACITY RATING OF THE POWER PLANT
2. FOR 3 HOUR RESERVE - D + F + G
   FOR 24 HOUR RESERVE - E + F + G
3. KW RATING FOR BH PEAK DRAIN

Figure 1.1 - Power Plant Data Sheet, Form SW-5073

OFFICE ____________
CITY ____________
SPEC NO ____________

BATTERY CAPACITY AGE CORRECTION CALCULATIONS FOR MULTIPLE STRINGS

DATE ____________
ESTIMATE REQUEST ____________

	____ VOLT PLANT BATTERIES YEAR INST/MAKE	STRING	LIST	(A) CAP A.H.	(B) PERCENT LOAD PER STRING (NOTE 1)	(C) AGE CORR. FACTOR PER STRING	(D) TOTAL AGE CORR. FACTOR (B X C)	(E) TOTAL DISCH DRAIN (NOTE 2)	(F) TOTAL DISCH DRAIN CORR FOR AGE (D X E)	(G) DISCH DRAIN PER STRING (B X F)	(H) HOURS RES PER STRING (NOTE 3)	
PRESENT 19__								X	X			FVPC ____
								X	X			
								X	X			
								X	X			
								X	X			
	TOTAL				X	X				X	X	
END OF POWER ENGR PERIOD 19__								X	X			FVPC ____
								X	X			
								X	X			
								X	X			
								X	X			
	TOTAL				X	X				X	X	
ESTIMATED 19__								X	X			FVPC ____
								X	X			
								X	X			
								X	X			
								X	X			
	TOTAL				X	X				X	X	

NOTES:

1. B=A(PER STRING) ÷ A(TOTAL)
2. RECORD FROM LINE "H" OF POWER PLANT DATA SHEET
3. IF ALL CALCULATIONS HAVE BEEN MADE CORRECTLY ALL STRINGS SHOULD HAVE THE SAME HOURS RESERVE, HOWEVER, DUE TO ROUNDING AND INTERPOLATION OF THE DISCHARGE CURVES AND TABLES THERE MAY BE A SLIGHT DIFFERENCE. USE THE AVERAGE TO RECORD ON LINE K OF THE POWER PLANT DATA SHEET.

Figure 1.2 - Age Correction Factor Calculation Sheet, Form SW-5074

Emergency Power Data Sheet

Office: ____________

E.R. ____________

	Present	End of Power Engr. Period	Estimated
	____	____	____
Telephone Equipment Load			
________ Plant, KW (AMPS)	____	____	____
________ Plant, KW (AMPS)	____	____	____
________ Plant, KW (AMPS)	____	____	____
________ Plant, KW (AMPS)	____	____	____
Inverter Plants	____	____	____
AC-Operated Ringing Machine	____	____	____
Other Telephone Equipment Load, KW	____	____	____
Essential Building Load			
Emergency Lighting, KW (AMPS)	____	____	____
Sump Pump, KW	____	____	____
Ventilating and Exhaust Fans, KW	____	____	____
Elevator, KW	____	____	____
Compressor-dehydrator, KW	____	____	____
Other (list), KW	____	____	____
________	____	____	____
________	____	____	____
	====	====	====
Total Load, KW	____	____	____
Size of Installed Engine(s), KW	____	____	____

Figure 1.3 - Emergency Power Data Sheet, Form SW-5075

1.4 Estimate Requests Having No Power Equipment Changes

In those instances where power equipment is not being added or removed under an estimate request, the "Power Plant Data" and "Emergency Power Data" sheets, forms SW-5073 and 5075, need not be included with the Vice President-Engineering's copy of the estimate request. However, the Telephone Company equipment engineer must still determine that the existing power equipment is adequate to handle all known requirements through the end of the power engineering period. In these cases, an updated copy of the office SWX-XXXX-550-G drawing or the data sheets will be included in the Chief Engineer's copy of the estimate request. The adequacy of the existing power plant equipment can be verified from this information.

PART C - SECTION 2.0
ACCOUNTING PROCEDURES

2.1 General

Power plant equipment accounting procedures are outlined in the Plant Accounting Handbook and Joint Practice 46. Of particular importance are section V27.301 of the Plant Accounting Handbook and Part 2B of Joint Practice 46. Section V27.301 lists the associated account codes for construction (C), maintenance (M) and removal (X) of power plant equipment. Part 2B covers the preparation of specific estimates by the Engineering Department, their routing for the required approval and their transmittal to the Vice President-Engineering.

In addition to these accounting sources, the Accounting Department or Engineering General Headquarters may issue accounting opinions or letters of clarification or recommendation.

Although treated as power equipment, ringing plants and associated tone equipment should be included in the predominant switching account code for the office in which located. Ringing plants in isolated circuit equipment locations should be included in the circuit equipment account codes (see Plant Accounting Handbook, section V27.301, part 12).

2.2 Specific Application: Emergency Cell Switch Replacement

When the size of an emergency cell switch bay is increased, a transition bay is usually required. The transition bay is normally cut into service temporarily to allow removal of the old switch and installation of the new switch. The cost of installing and removing the transition bay should be charged to the capital (C) account. The transition bay itself is usually obtained from "C" stock or by transfer from another location. After the transition is completed it should be disposed of by either returning it to "C" stock on a RMN or transferring it to another location via an SW5015. Generally in this type of transition a large amount of power cable is used to cable between the transition bay in parallel with the existing bay. This cable is usually of such a size as to be classified as a unit of property. After the transition the surplus cable should either be returned to the Western Electric Company on a RMN for best allowance or transferred along with the switch to another location.

Since the transition bay is used only temporarily in place of the existing bay it should not be transferred to plant (100.1 account) and the bay being removed should not be retired until the new permanent bay is placed in service.

PART C - SECTION 3.0

BELL-INDEPENDENT PROCEDURES

Reserved for future use.

PART D - SECTION 1.0

GENERAL REQUIREMENTS FOR SPECIFICATIONS

1.1 Requirements for Power Equipment Section

The Telephone Company equipment engineer is responsible for ordering from Western Electric all major items of power equipment. The Telephone Company specification is the document used to outline to the Western Electric engineer the specific changes to be made in an office's power equipment (these requirements are usually included in a separate section of the specification).

Various formats have been used in the past to transmit this information to Western Electric engineering. Two power questionnaires (E1896 for dial, manual and toll offices; E1896P for No. 1 and No. 2 ESS offices) are available for use in specifying requirements. As can be seen in figure 1.1, the power questionnarie not only permits designation of required quantities of equipment but also allows selection among various operating options. Since considerable effort is required to complete the "note" sections of the questionnaire, many specifications incorporate only the "quantity" section of the questionnaire format (present, additional and total quantities) and leave selection of the various operating options to the discretion of the Western Electric engineer. The Telephone Company equipment engineer is responsible for selecting among the various operating options and, in delegating this responsibility to the Western Electric engineer by omitting them from the Telephone Company specification, runs the risk of not having the plant engineered as it was intended.

In many instances, no attempt has been made to keep a running record of power equipment (i.e., present, additional, total quantities). Entries are sometimes made only if power equipment is being added, removed or modified. In many cases, the power section of the specification will reflect "No Change" indicating that no changes in power equipment are required under this specification.

In the future, all new power plants should be engineered using the questionnaire format. Existing power equipment should be inventoried in conjunction with the next growth job and the power equipment section revised to include at least present, additional and total figures for all major items of equipment listed in the questionnaire. If at all possible, the note sections should also be updated to reflect the presently engineered plant. For older plants not included in questionnaries, the power equipment section should include present, additional and total quantities for all major components in the plant.

In addition to listing equipment quantities and operating options, the power equipment section of the specification should also include the following statement: The addition (removal) of equipment under this specification results in the following increase (decrease) in power drain:

-48 volts - X amps -24 volts - X amps	List all voltages and respective drains

ITEM ORDER NO.______________ SECTION________ PAGE________

ITEM			PRES	ADDNL	TOT	NOTE	"Y" NOTE
____	302A / B NEG 24V / & / NEG 48V POWER PLANT						
	MAIN CONTROL BOARD, 24V / 48V / 24V & 48V EQUIPPED WITH		____	____	____	____	5,129,133
	24V THRU CEMF CELLS	_ _ _ _ _ _ _ _ _,				____	
	24V MANUAL / AUTOMATIC EM CELL SWITCHING	_ _ _ _ _ _ _ _ _,				____	
	48V MANUAL / AUTOMATIC EM CELL SWITCHING	_ _ _ _ _ _ _ _ _,				____	
	24V MANUAL / AUTOMATIC START CONTROL	_ _ _ _ _ _ _ _ _,				____	
	48V MANUAL / AUTOMATIC START CONTROL	_ _ _ _ _ _ _ _ _,				____	
	ALM EQPT FOR FLOOR PILOT LT	_ _ _ _ _ _ _ _ _,	____	____	____		
	ALARM CUTOFF	_ _ _ _ _ _ _ _ _,					
	HIGH VOLTAGE SHUTDOWN	_ _ _ _ _ _ _ _ _,					
	GENERATOR CUTOFF	_ _ _ _ _ _ _ _ _,					
	POWER SERVICE FAILURE TRANSFER CKT	_ _ _ _ _ _ _ _ _,					
	REMOTE SHUTDOWN OF CHARGE UNITS AT RESERVE ENG ALT	_ _ _ _ _ _ _ _ _,					
	ENG ROOM EXTENSION ALARMS	_ _ _ _ _ _ _ _ _,					
	CODED ALM SIGNAL	_ _ _ _ _ _ _ _ _.					

NOTE____PLANT IS / SHALL / NOT / BE MODIFIED TO REDUCE CHATTER OF EM CELL VOLTAGE RELAY.

NOTE____PLANT IS / SHALL / NOT / BE MODIFIED SO VOLTAGE REGULATED CHG UNIT G-1 OR G-2 OPERATE AS 2 STEP CURRENT REGULATED CHARGE UNIT.

NOTE____PLANT IS / SHALL / NOT / BE MODIFIED TO REMOVE CEMF CELLS.

Figure 1.1 - Typical Power Questionnaire

If more than one plant in a building supplies a given voltage, be sure to specify which plant will experience the additional load.

1.2 Requirements for Supplementary Information Section

The "Supplementary Information" section of the specification should also include a reference to the issue of the SWX-XXXX-550-G drawing associated with the power equipment rearrangements.

PART E - SECTION 1.0

INTRODUCTION TO REFERENCE SECTION

1.1 Purpose

This part of the power plant practice lists current reference sources available for use in power plant engineering.

PART E - SECTION 2.0

REFERENCE SOURCES

2.1 Power Plant Cross Reference

The following table lists the cross reference data for the most widely used power plants.

Plant Code	BSP	J-Code	Charge (C) and Discharge (D) Circuits	Nominal Voltage
105D	802-656-152	J86446	SD-81134-01 (C&D)	-48V
105E	802-656-153	J86814	SD-81591-01 (C&D)	±48V
			SD-81603-01 (C&D)	±24V
110A	802-659-150	J86572	SD-80720-02 (D)	-48V
			SD-80722-02 (C)	-48V
			SD-81270-01 (C)	-48V
			SD-81271-01 (D)	-48V
			SD-80753-01 (D)	-24V
			SD-80755-01 (C)	-24V
111A	802-659-160	J86470	SD-81424-01 (C&D)	±48V
			SD-81501-01 (C&D)	±48V
			SD-81613-01 (C&D)	±48V
			SD-81446-01 (C&D)	±24V
			SD-81612-01 (C&D)	±24V
			SD-81769-01 (C&D)	±24V
301C	AA367.302	J86573	SD-80603-01 (C&D)	-48V, -24V
302A	802-726-150	J86434	Gen. Description	-24V, -48V
302B	802-726-151	J86636	Gen. Description	-24V, -48V
302A/B	802-175-150	J86323	SD-80838-01 (D)	-24V
			SD-81175-01 (C)	-24V
			SD-81121-01 (D)	-48V
			SD-81148-01/02 (C)	-48V
			SD-81234-01 (D)	-24V, -48V
303A	802-185-153	J86327	SD-81448-01 (C&D)	-24V, -48V
326A	802-727-150	J86874	SD-81861-01 (C&D)	+24V, -48V
405A	AA367.404	J86585	SD-80642-01 (C&D)	+130V
			SD-80642-02 (C&D)	-130V
410A	802-754-150	J86584	SD-80942-01 (D)	±130V
			SD-80943-01 (C)	

Plant Code	BSP	J-Code	Charge (C) and Discharge (D) Circuits	Nominal Voltage
410B	802-754-151	J86465	SD-81293-01 (C&D) (63 cell)	±130V
			SD-81294-01 (C&D) (66 cell)	
			SD-81295-01 (C&D) (70 cell)	
411A	802-754-160	J86862	SD-81618-01 (C&D)	±130V
411B	802-754-161	J86863	SD-81618-01 (C&D)	±130V
412A	802-755-150	J86864	SD-81618-01 (C&D)	±130V
412B	802-755-151	J86865	SD-81618-01 (C&D)	±130V
413A	802-755-160	J86826	SD-81651-01 (C&D)	±152V
425A	802-759-153	J86435	Gen. Description	-
	802-759-151	J86439 (A&M)	SD-81086-01 (C&D)	-12V
	802-759-152	J86832 (STD)	SD-81732-01 (C&D)	-12V
	802-601-152	J86440 (STD)	SD-81091-01 (C&D)	-24V
	802-759-154	J86437 (A&M)	SD-81084-01 (C&D)	+130V
	802-759-155	J86438 (A&M)	SD-81085-01 (C&D)	+250V
	802-759-156	J86837 (STD)	SD-81730-01 (C&D)	+250V
425B	802-759-160	J86452	Gen. Description	-
	802-759-161	J86450	SD-81161-01 (C&D)	-12V, +250V
	802-759-162	J86449	SD-81167-01 (C&D)	+130V
	802-601-152	J86440	SD-81179-01 (C&D)	-24V
426A	802-760-150	J86442	SD-81137-01 (C&D)	±130V
702C	802-871-150	J86475	Gen. Description	±130V
	802-175-152	J86326	SD-81333-01 (C)	±130V
	802-185-151	J86325	SD-81015-01 (D)	±130V
			SD-81022-02 (D)	±130V
			SD-81023-02 (D)	±130V
708A	802-874-150	J86827	SD-81696-01 (C&D)	±130V

2.2 List 1 Current Drain Book

The List 1 Current Drain Book is a Bell Telephone Laboratories' document. List 1 drains, in general, are those applicable to the computations of power apparatus in the common portion of the power plant. It lists the current drains for most circuits and KS specifications and is used by the Telephone

Company engineer in calculating anticipated drains for added equipment.

2.3 Power Data Book

The Power Data Book is a Bell Telephone Laboratories' document which outlines the physical and electrical characteristics of most KS-coded and other miscellaneous non-J-coded power equipment and apparatus. This book covers such representative items as batteries, switches, bus bar, bus duct, transformers and emergency cell switches. The index contains a cross reference listing of all the KS items and the sections in which information about them may be located.

2.4 Floor Plan Data Book

The Floor Plan Data Book is a Bell Telephone Laboratories' document which outlines preferred floor plan layouts for the various types of power plants, emergency engines, ringing plants and other equipment frames. The Telephone Company equipment engineer may refer to this book when deciding upon floor plan layouts.

2.5 Questionnaire For Power Plant

The "Questionnaire For Power Plant" is a Western Electric Company document. There are presently two questionnaires in use: 1) E-1896 - Dial, Manual and Toll Offices, and 2) E-1896P - No. 1 and No. 2 ESS Offices. These forms are to be used in ordering power equipment for installation in telephone offices and may be used for initial power plant orders or for additions to existing installations. They also contain various cross references and descriptive information. New or revised questionnaires may be issued from time to time by the Western Electric Company.

2.6 Power Engineering Manual

The Power Engineering Manual (green book) is an AT&T publication which serves as a reference manual for all phases of power engineering. It has not, however, been updated since its original issue in 1967 and therefore does not contain all current information. Where the forms and planning methods used in this manual differ from those in this practice, the procedures in this practice should be used.

2.7 Bell System Practices (BSP's)

BSP's are issued by Bell Telephone Laboratories for all standard coded equipment and provide descriptive, ordering and maintenance information. The BSP's are divided into divisions and sections, with division 000, section 000-000-000 being the master index. Division 802, section 802-000-000 is the index for Equipment Design and General Equipment Requirements and Engineering Information - Power Systems. Each of the individual equipment design BSP's list the associated J, SD and ED drawings.

The maintenance BSP's outline the maintenance and testing procedures for all types of standard equipment items and subunits and are listed in the 000-000-000 master index. Certain of the maintenance BSP's are supplemented with Southwestern Bell supplements in order to clarify Southwestern Bell's practices or policies (these supplements are normally printed on gold stock and will have an "SW" designation following the BSP number).

2.8 Engineering Letters

Engineering letters (E.L.'s) are issued by the AT&T Company and are sequentially numbered. They are used to transmit recommendations, preliminary design information, preliminary cost data, equipment modifications, and other engineering information. The E.L.'s are reviewed by Engineering General Headquarters personnel and are transmitted to the Areas with a cover letter signed by the Vice President-Engineering. This cover letter outlines Southwestern Bell's policies and recommendations regarding the information contained in the E.L.

Prior to E.L.'s, E.M.'s, P.E.L.'s and P.E.M.'s were used by AT&T to transmit this information to the Operating Companies. Both a numerical and topical index are published for E.L.'s.

2.9 Annual D.C. Power Drain Study (Form SW6623)

As outlined in BSP 157-601-902 SW, the Plant Department is required to perform annual drain studies on all in-service DC power plants and submit the results to the Chief Engineer on form SW6623 (form S6864 was previously used for this purpose). Procedures for completion and review of this form are included in part B, section 4.2.

2.10 Emergency Engine Sets Prolonged Load Test Results (Form S6956)

BSP 155-010-901 SW requires the Plant Department to perform annual load tests on all in-service emergency engines and submit the results to the Chief Engineer on form S-6956. Procedures for completion and review of this form are outlined in part B, section 8.17.

2.11 SWX-XXXX-550-G Drawing

An SWX-XXXX-550-G drawing is prepared by the appropriate Telephone Company equipment engineer for each location equipped with power plant equipment. The 550 drawing lists the basic data and capacities for all power plant equipment installed at each location including drain and load data; and code, size and capacity of the DC power plants, inverters, converters, ringing and tone plants and emergency engines. Part B, section 3.0 of this practice provides instructions for completing the various parts of the SWX-XXXX-550-G drawing.

2.12 Correspondence Files

These files consist of letters and other miscellaneous correspondence which are normally filed in one of two ways: by numerical file index or alphabetically in a geographical file (by location). General information or policy pertaining to more than one location is usually filed in the numerical file (although it may also contain information pertaining to only one location). Information or correspondence filed in an office's geographical file will always pertain to that office (although other offices may also be referenced).

The "Numerical and Alphabetical - File Index - Engineering Department" lists all of the current numerical file index subjects. They are cross-referenced by both topic and index number. Index 1B10. is reserved for power matters and contains the following subindexes:

1B10.	Power/No. File
1B10.01	Power Board Equipment and Power Plant
1B10.03	Charge/No. File
1B10.03A	Motors and Motor Generators
1B10.03C	Rectifiers
1B10.04	Batteries
1B10.05	Ringing Machines
1B10.07	Emergency Engines

2.13 Currently Available Reserve Power, Engine-Alternator Schedule

A complete list of standard and manufacture discontinued engine alternators is contained in this publication distributed by the General Architectural group in St. Louis. This publication lists all standard engines, their capacities, operating characteristics and sources for additional information.

This list is updated and distributed to all Building and Equipment Engineers as new information becomes available. The latest copy can be found in the engineering library under file subject 1A2.08 or 1B10.07. This list serves as an update of information contained in BSP 802-001-150.

2.14 Specifications (W.E. Co. and Telephone Co.) and Drawings

The Western Electric Company and Telephone Company specifications list the actual equipment that was or is to be ordered and furnished. The Telephone Company specifications are filed by location and specification number. The Western Electric Company (W.E. Co.) specifications are filed by location and W.E. Co. order number. Part D of this practice outlines the information that is to be included and format that is to be used in Telephone Company specifications ordering or updating power equipment data.

The W.E. Co. office or location power drawing generally includes the floor plan layout, front equipment, wiring lists, bus bar layouts (if applicable), and AC power service cabinet layout and distribution. The Office Record Index (ORI) drawing for each office or location lists all associated power equipment drawings. The ORI drawing is coded T-XXXX-ORI-00 (XXXX - office base number). In large offices that contain more than one office or type of equipment, (such as No. 1 ESS, No. 5 Crossbar, No. 4A Crossbar, circuit) a separate base number and ORI drawing may exist for each equipment entity.

The Telephone Company power drawings generally include the floor plan layout and the architectural AC electrical layout. The floor plan layout is usually coded SWX-XXXX-XXX (XXXX - office base number, XXX - floor, as 103 indicating the third floor). The architectural drawings are usually retained by the Architectural group and filed by wire center name.

2.15 Policy Binder

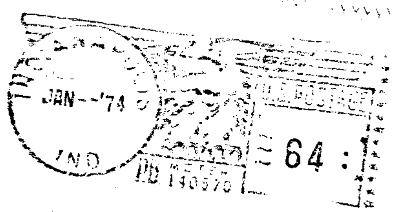
The Engineering Director - Staff's organization is responsible for distribution of the new "Policy Binder" which summarizes current policy in all areas of engineering. This "Policy Binder" lists (by engineering categories) current policy letters, provides a brief synopsis of the letter and outlines the date and file subject under which the letter was issued. Power policy letters are listed in the "Central Office Equipment" section of the binder.

PART F - POLICY FILE

This part will be used to record and file new power policy letters which have not yet been incorporated in the text of this practice.

Page	Item

INDEX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