DC Power Distribution

1. General

This addendum is issued to change and/or supplement the information contained in Bellcore Practice BR 790-100-656, DC Distribution. Issue B changes guidelines for sizing fuses, adds engineering considerations and standards for Battery Distribution Fuse Boards (BDFB), and provides information on DC distribution to collocation areas. This is a merged practice (MP), and provides standards for Southwestern Bell, Pacific Bell, Nevada Bell, Ameritech, and Southern New England Telephone (SNET).

1.1 Definitions

Daisy Chaining/Equalizing Center: Daisy Chaining or an Equalizing Center is the practice of feeding multiple equipment applications without the benefit of circuit protection devices for each individual feed.

Branch Feeding: Branch Feeding is the practice of feeding multiple equipment applications in a branch style connection with the benefit of intermediate circuit protection.

BDCBB: A Battery Distribution Circuit Breaker Bay is the second point of circuit protection and marks the separation between primary and secondary power. This bay uses circuit breakers as the protection device.

BDFB: A Battery Distribution Fuse Bay is the second point of circuit protection and marks the separation between primary and secondary power. This bay uses fuses as the protection device.

2. Cable and Bus Bars

2.1 Product Requirements

2.1.1 Only approved cable is to be used in a DC distribution system. See the current list of approved products for approved cables.

2.1.2 All new cable and all new bus bars shall be copper.

2.2 Cable Sizing

2.2.1 The size of a power lead depends upon the amount of current it must ultimately carry. Cable shall be sized based upon MVPC of the plant.

Details involved with MVPC regulations can be located in the BSP 790-100-655MP. Cable size is calculated as follows;

$$CM = \frac{(\sigma) * I * L}{V}$$

CM	=	Circular Mil area of the cable
σ	=	Conductivity factor for copper cable, (11.1)
I	=	Peak List 2 Drain
L	=	One-way length of cable in feet
V	=	Allowable voltage drop one-way

2.2.2 If multiple conductors are required for voltage drop reasons they shall be electrically joined at both ends to form a single conductor and meet the following conditions;

- Same length
- Same conductor material
- Same size in CM area
- Same insulation

2.2.3 Cable Sizing Chart

TABLE 12-1--CABLE SIZES

WIRE SIZE		AMPACITY
GAUGE	CM	(COPPER)
14	4110	15*
12	6530	20*
10	10380	30*
8	16510	55
6	26250	75
4	41470	95
2	66370	130
0	105600	170
00	133100	195
0000	211600	260
350 MCM	350000	350
500 MCM	500000	430
750 MCM	750000	535

Source: National Electrical Code (NEC) Handbook, 1996, Table 310-16

The ampacity values reflected here are standard copper wire/cable values

Please refer back to the NEC Handbook for standards on any non standard wire/cable

- Allowable ampacity may be effected by items such as insulation rating -

*Maximum fuse size

2.3 Busbar Sizing

2.3.1 Busbar shall be sized based upon MVPC of the plant. Details involved with MVPC regulations can be located in the BSP 790-100-655MP.

Busbar sizing chart

# OF BARS	THICKNESS OF BARS	WIDTH OF BARS	AREA IN CM	ALUMINUM				COPPER			
	IN INCHES			AMPACITY		LBS PER FT.	Microhms Per Foot. @ 70 C	AMPACITY		LBS. PER FT.	Microhms Per Foot. @ 70 C
1	1/8	1/2	29.60	114	112	0.07	271.6	154	152	0.242	159.49
1	1/8	3/4	119.4	159	157	0.11	180.9	215	212	0.362	106.32
1	1/8	1	159.2	203	200	0.15	135.8	275	271	0.483	79.74
1	1/8	1 & 1/2	238.7	287	283	0.22	90.54	390	385	0.725	53.16
1	1/8	2	318.3	370	364	0.29	67.91	503	496	0.966	39.87
1	1/4	1/2	159.2	177	174	0.15	135.8	238	234	0.483	79.74
1	1/4	1	318.3	302	297	0.29	67.91	409	403	0.966	39.87
1	1/4	1 & 1/2	477.5	471	415	0.44	45.27	572	564	1.45	26.58
1	1/4	2	636.6	537	529	0.59	33.95	731	721	1.93	19.94
1	1/4	2 & 1/2	795.8	651	636	0.73	27.16	887	869	2.42	15.95
1	1/4	3	954.9	762	746	0.88	22.63	1040	1019	2.9	13.29
1	1/4	3 & 1/2	1,114.00	873	841	1.03	19.4	1192	1152	3.38	11.39
1	1/4	4	1,273.00	982	946	1.17	16.98	1342	1298	3.86	9.97
1	1/4	6	1,910.00	1408	1320	1.76	11.32	1931	1820	5.8	6.65
1	1/4	8	2,546.00	1823	1649	2.34	8.49	2506	2292	7.73	4.98
1	3/8	1	477.5	387	381	0.44	45.27	524	517	1.45	26.58
1	3/8	1 & 1/2	716.2	533	525	0.66	30.18	724	714	2.17	17.72
1	3/8	2	954.9	675	665	0.88	22.63	919	906	2.9	13.29
1	3/8	2 & 1/2	1,194.00	814	796	1.1	18.11	1110	1087	3.62	10.63
1	3/8	3	1,452.00	951	960	1.32	15.09	1298	1272	4.35	8.85
1	3/8	4	1,910.00	1219	1175	1.76	11.32	1667	1612	5.8	6.65
1	3/8	6	2,865.00	1740	1629	2.64	7.55	2388	250	8.69	4.43
1	3/8	8	3,820.00	2248	2035	3.52	5.66	3092	2828	11.59	3.32
1	1/2	1	636.6	466	459	0.59	33.95	632	622	1.93	19.94
1	1/2	1 & 1/2	954.9	636	626	0.88	22.63	863	851	2.9	13.29
1	1/2	2	1,273.00	800	788	1.17	16.98	1088	1073	3.86	9.97
1	1/2	3	1,910.00	1118	1093	1.76	11.32	1525	1494	5.8	6.64
1	1/2	4	2,546.00	1427	1376	0.34	8.49	1951	1887	7.73	4.98
1	1/2	6	3,820.00	2029	1899	3.52	5.66	2783	2623	11.59	3.32
1	1/2	8	5,093.00	2615	2366	4.69	4.25	3596	3289	15.46	2.49
2	1/4	2	1,273.00	969	935	1.18	16.98	1301	1259	3.86	9.97
2	1/4	3	1,910.00	1363	1285	1.76	11.32	1834	1735	5.8	6.65
2	1/4	4	2,546.00	1745	1596	2.34	8.49	2350	2163	7.72	4.98
2	1/4	6	3,820.00	2483	2152	3.52	5.66	3352	2937	11.6	3.32
2	1/4	8	5,093.00	3198	2605	4.68	4.25	4325	3583	15.46	2.49
2	1/2	2	2,546.00	1458	1411	2.34	8.49	1961	1902	7.72	4.98
2	1/2	3	3,820.00	2015	1906	3.52	5.66	2715	2577	11.6	3.22
2	1/2	4	5,093.00	2555	2346	4.68	4.24	3445	3182	15.46	2.49
2	1/2	6	7,639.00	3597	3131	7.04	2.83	4861	4275	23.2	1.66
2	1/2	8	10,186.00	4608	3770	9.38	2.12	6236	5189	31.92	1.25
3	1/4	2	1,910.00	1397	1336	1.77	11.32	1865	1787	5.79	6.65
3	1/4	3	2,865.00	1957	1813	2.64	7.54	2616	2432	8.7	4.43

3	1/4	4	3,820.00	2496	2226	3.51	5.66	342	296	11.58	3.32
3	1/4	6	5,730.00	3543	2947	5.28	3.77	4745	3992	17.4	2.22
3	1/4	8	7,640.00	4552	3495	7.02	2.83	6105	4770	23.19	1.66
3	1/2	4	7,640.00	3670	3291	7.02	2.83	4918	437	23.19	1.66
3	1/2	6	11,460.00	5146	4311	10.56	1.88	6902	5848	34.77	1.11
3	1/2	8	15,280.00	6572	5083	14.07	1.42	8824	6950	46.38	0.831
4	1/4	2	2,546.00	1823	1735	2.16	8.49	2426	2313	7.72	4.89
4	1/4	3	3,820.00	2549	2337	3.52	5.66	3394	3123	11.6	3.32
4	1/4	4	5,093.00	3249	2850	4.58	4.25	4328	3819	15.44	2.49
4	1/4	6	7,639.00	4598	3728	7.04	2.83	6130	5026	23.2	1.66
4	1/4	8	10,186.00	5899	4354	9.16	2.12	7872	5916	30.92	1.24
4	1/2	4	10,186.00	4782	4228	9.36	2.12	6384	5679	30.92	1.25
4	1/2	6	15,280.00	6688	5473	14.08	1.42	8933	7392	46.36	0.831
4	1/2	8	20,372.00	8527	6362	18.76	1.06	11395	8659	61.84	0.623
5	1/4	4	6,365.00	3999	3471	5.85	3.4	5312	4637	19.3	1.99
5	1/4	6	9,550.00	5650	4502	8.8	2.26	7512	6048	29	1.33
5	1/4	8	12,730.00	7242	5202	11.75	1.7	9634	7041	38.65	0.99
5	1/2	4	12,730.00	5892	5161	11.7	1.69	7847	6915	38.65	0.997
5	1/2	6	19,10.0	8227	6626	17.6	1.13	10960	8921	57.95	0.665
5	1/2	8	25,460.00	10475	7624	23.45	0.849	13960	10340	77.3	0.498
6	1/4	4	7,640.00	4748	4090	7.04	2.83	6295	5452	23.16	1.66
6	1/4	6	11,460.00	6702	5273	10.6	1.89	8891	7064	34.8	1.11
6	1/4	8	15,380.00	8585	6043	14.15	1.42	11395	8154	46.38	0.83
6	1/2	4	15,280.00	7002	6092	14.04	1.42	9309	8148	46.38	0.831
6	1/2	6	22,920.00	9765	7775	21.12	0.943	12980	10445	69.54	0.554
6	1/2	8	30,560.00	12425	8876	28.14	0.707	16520	12005	92.76	0.415
7	1/4	6	13,370.00	7753	6041	12.32	1.62	10270	8076	40.6	0.95
7	1/4	8	17,822.00	9926	6878	16.38	1.21	13150	9259	54.11	0.71
7	1/2	6	26,740.00	1130	8921	24.64	0.808	15000	11860	81.13	0.475
7	1/2	8	35,644.00	14345	10120	32.83	0.606	19080	13660	108.2	0.356
8	1/4	6	15,280.00	8804	6808	14.08	1.42	11645	9086	46.4	0.83
8	1/4	8	20,372.00	11265	7711	18.72	1.06	14905	10760	61.84	0.62
8	1/2	6	30,560.00	12840	10065	28.16	0.707	17020	13475	92.72	0.415
8	1/2	8	40,744.00	16320	11365	37.52	0.53	21635	15310	123.7	0.313
9	1/4	6	17,190.00	9854	7575	15.84	1.26	13020	10095	52.2	0.74
9	1/4	8	22,914.00	12605	8541	21.06	0.94	16660	11455	69.57	0.55
9	1/2	6	34,380.00	14375	11205	31.68	0.629	19040	14985	104.3	0.369
9	1/2	8	45,828.00	18265	12605	42.21	0.472	24190	16955	139.1	0.277
10	1/4	6	19,100.00	10905	8338	17.6	1.13	14400	11100	58	0.67
10	1/4	8	25,460.00	13945	9369	23.4	0.85	18415	12545	77.3	49
10	1/2	6	38,200.00	15910	12350	35.2	0.566	21060	16495	115.9	0.332
10	1/2	8	5,920.00	20210	13840	46.9	0.424	26745	18600	154.6	0.248
11	1/4	6	21,010.00	11955	9102	19.36	1.03	15775	12105	63.8	0.6
11	1/4	8	28,006.00	15285	10195	25.74	0.77	20170	13640	85.03	0.45
12	1/4	6	22,920.00	13005	9866	21.12	0.94	17150	13110	69.86	0.55
12	1/4	8	30,560.00	16625	11025	28.08	0.71	21925	14725	92.86	0.41

3.0 Protection Devices

3.1 For new primary distribution equipment used in central office applications, fuses are recommended for all circuits of 226 amps and above. Existing primary distribution equipment may have either a fuse or circuit breaker for circuits with loads of 225 amps or less. Cartridge type fuses shall have an interrupting rating of 100,000 amps.

3.2 For RT power applications, fuses or circuit breakers may be used as a primary protection device.

3.3 It is not recommended that any new 'switch and fuse' units be installed based upon their cost and size.

3.4 All Telpower style fuse blocks shall be provisioned with an alarm feature that indicates an operated fuse. The alarm fuses shall all be equipped with .18 fuses.

3.5 All circuit breakers shall be equipped with an alarm feature that indicates when the breaker has operated and is in a 'tripped' position.

3.6 The SBC LEC Power Equipment Engineer shall design the distribution to any remote bay with a minimum of one primary protection device prior to the distribution bay.

4.0 Electrical Protection

4.1 Protection Sizing

4.1.1 The SBC LEC Power Equipment Engineer shall provide protection sized based upon each circuits peak current drain and the distribution cable size. The actual size of the cables provided must have an ampacity equal to or greater than the protector size selected.

4.1.2 The SBC LEC Power Equipment Engineer shall design the distribution system protection to ensure that the protector nearest a fault operates before any upstream protector operates.

4.1.3 The SBC LEC Power Equipment Engineer shall engineer the minimum fuse size as 125% of the List 2 drain documented for the load being protected. DC distribution circuit breakers are full load rated, if used, a circuit breaker may be of the same capacity as the List 2 drain. At no time shall the actual load exceed 50% of the fuse or DC breaker protection rating.

4.2 Distribution Engineering

4.2.1 The practice of daisy chaining power leads shall not be accepted.

4.2.2 The use of secondary fuse panels, beyond the BDFB as a form of branch feeding is allowable. Distribution to equipment outside the immediate bay location of the panel is acceptable as long as it is within a close proximity of the fuse panel (e.g. less than 9 cable feet). Exact distances will vary from panel to panel. Distances shall be calculated by determining the largest conductor physically attachable to the panel (H-tapping a larger cable to increase the distance is not acceptable), appropriate voltage drop, and the List 2 DC amperage value to be used per fuse position.

For example: If the serving equipment's List 2 requirements are 12.5 amps served with 15-amp fuse, based on the manufacturer specification of the distribution panel, the largest conductor physically attachable is a #10 AWG cable and connector. Using a voltage drop of .25, the allowable one way cable length would be 9 cable feet.

4.2.3 Going forward the use of BDCBB's is not recommended for DC power distribution. New installations in the central office environment shall use BDFB's. Therefor through this document we will refer to any battery distribution bay as a BDFB.

4.2.4 Central office switching systems may be designed with internal secondary distribution centers. The switch manufacturer names these distribution centers. They may be referred to as a PDC, or GPDF as well as others.

4.2.5 The SBC LEC Power Equipment Engineer must consider the size of the loads to be served when placing the BDFB. Traditionally the fuse size within secondary distribution ran 1 to 70 Amps. With increases fuse size requests from Transport, Data, and Collocation fuse sizes from 71 – 150 Amps are being needed. It is highly recommended that these loads are fed from a BDFB vs. the main power board. The added protection of the secondary distribution network is needed to protect the main power board from faults.

4.2.6 The maximum allowable one way voltage drop from battery to equipment served is 1-volt, with the return included it is a total of a 2-volt drop. The one way voltage drop at the BDFB shall not exceed .75 volts. The remaining voltage drop budget (.25 volt or greater) is calculated by subtracting the total voltage drop at the BDFB from the 1-volt maximum one way drop.

4.2.7 The actual voltage drop at the BDFB shall be recorded with the appropriate central office records (stenciled on the BDFB, office drawings or mechanized database). The remaining voltage drop shall be used to size

all power feeds for transport, collocation and data equipment. All cable sizing for these feeds shall use the full remaining voltage drop budgeted to ensure the most economical distribution system.

4.2.8 All BDFB's shall be engineered for a maximum allowable load of 300 A per feed. The corresponding maximum allowable fuse size being 600 A per feed. The SBC LEC Power Equipment Engineer shall verify that the manufacturers rating for the BDFB's internal bus equals or exceeds the rating of the primary fuse feeding the bus.

4.2.9 The SBC LEC Power Equipment Engineer shall determine when the growth of any BDFB is capped based upon the actual measured load. During normal operating conditions the actual measured load per feed shall not exceed 50% of the engineered load capacity. Typical examples of this are as follows;

- A BDFB cabled and fused for 600 A per bus shall not exceed an actual measured load of 300 A per feed.
- A BDFB cabled and fused for 400 A per bus shall not exceed an actual measured load of 200 A per feed.

4.2.9 All full size BDFB's shall be fused with a minimum of four separately protected primary feeds ('A','B', 'C', 'D') and all mini BDFB's with a minimum of two primary feeds ('A', 'B') unless otherwise stipulated within the TEO by the SBC LEC Power Equipment Engineer. The primary protection device for each feed shall be a maximum of 600A. The BDFB load shall be monitored to ensure that the actual load supplied by any single feed does not exceed 50% of the nameplate rating on that primary protection device. It is the responsibility of the SBC LEC Power Equipment Engineer to close a BDFB to growth when it's load has reached that value.

4.2.10 The SBC LEC Power Equipment Engineer should see very similar loads between the loads on 'A' and 'B' or 'C' and 'D' feeds within any given BDFB. Any large variations, those being greater than 15%, in load between bus A and bus B should be investigated.

4.2.11 All assignments for floor space are made by the Common Systems Planning & Engineering Center (CSPEC). However, it is the responsibility of the SBC LEC Power Equipment Engineer to work with CSPEC to determine the optimal location for new BDFB's. After the appropriate location for the new BDFB has been determined, the SBC LEC Power Equipment Engineer shall acquire the proper identification number for the newly installed BDFB from the CSPEC.

5.0 Secondary Distribution

5.1 Secondary distribution is defined as fuse requirements beyond the BDFB. Generally, secondary distribution is of smaller caliper.

5.2 Secondary distribution has been provided through the use of fuse bays. The older style fusing, usually containing 35-type fuses has been used for many years. With the advent of the distribution fuse panel, the use of this style of fusing has discontinued and should be eliminated through attrition.

5.3 This distribution fuse panel can be described as, but not limited to, dual A/B loads with a minimum of 10 GMT or 70 type fuse positions. Many GMT type fuse panels can be equipped with up to 15 amp fuses. Listings of fuse panels approved for use in the SBC LEC can be found on the Common System web page http://home.sbc.com/commonsystems/.

5.4 While engineering a secondary distribution fuse panel beyond the BDFB, under no circumstances should the BDFB fuse serving the fuse panel be sized larger than the manufactures rating.

For Example: A fuse panel equipped with A/B loads has manufacturers rating of 60 amps per load. The BDFB fuses shall not be larger than 60 amps

6. Collocation

6.1 Under various Federal Communication Commission (FCC) and Public Utility Commission orders, Competitive Local Exchange Carriers (CLEC's) are allowed to place telecommunications equipment in central offices and remote terminals. The arrangements are provided either as Physical Collocation, where space is leased for placing equipment and self-maintenance by the CLEC, or as Virtual Collocation, where the equipment is placed directly in to existing equipment line ups.

6.2 With either physical or virtual collocation in SBC LEC facilities, the SBC LEC as a matter of company policy provides power. This is primarily a fire and personnel safety issue.

6.3 With virtual collocation, power distribution is provided just as if the equipment were our own.

6.4 With physical collocation, -48 volt DC power is normally provided in increments defined per state tariffs where they exist, or in increments described as "standard power arrangements" in the Technical Publication for Physical Collocation. While the increments may vary from state to state, all are characterized as redundant (load A and load B) arrangements of specific amperage.

For Example: A collocator requests 40-amp service. The provisioning equates to a 40-amp redundant feed, consisting of a 40 amp 'A' and a 40 amp 'B'. The total current draw shall not exceed the 40-amps requested on the application.

6.5 The power increments described in 6.4 above should be provided from a BDFB whenever possible when the use of a BDFB is not possible they may be fed directly from the main Battery Control Board.

6.6 Previous guidelines have only allowed for the full load capacity of a collocation BDFB to be assigned and not to be exceeded. Thus, in California where 40 amp circuits were tariffed, a maximum of 10 such circuits could be assigned to a 400-amp load, and the BDFB was considered capped. Further evaluation of this practice has concluded that this policy provides a higher level of safety and security that provided for ourselves. Regulatory agencies have recognized that parity in service is acceptable. Furthermore, BDFB capacity for all users whether dedicated or shared shall follow the same capacity guidelines as defined in Section 4 of this document.

6.7 If a Collocator requires a "non-standard" power arrangement, such as a large power feed or isolated ground, the request shall be considered on an "Individual Case Basis". Technical staff may be consulted as special engineering or cost considerations may apply.

6.8 Further definition of power delivery regarding collocation can be found in the Collocation Implementation Guideline and the respective state or region Collocation Handbooks.

6.9 Further definition of power delivery regarding collocation may be found within the 'Collocation Provisioning Guidelines' and the appropriate state Collocation Handbooks.

6.10 Specific language has been adopted in the collocation guidelines, applications and handbooks to include the following statement:

"*Load specified by the collocator represent the peak current that will be imposed upon a power feeder at any voltage within the emergency operation limits of the equipment and any normal operating conditions (i.e. not a short circuit or other malfunction). Even though circuit design is based upon peak current, DC power plant design sizing by the SBC LEC Equipment Engineer is based upon demand management."*