

Facility Rating Methodology and Communication

For

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NOTE: WHEN REVISING THIS PROCEDURE ENSURE LATEST REVISION IS UPLOADED TO THE PUBLIC OASIS SITE.

Revision No.	Revision History	Date Revised
0	Original Issue	12/14/2005
1	Added signature page, revision history page, generator rating information and a section on communicating the use of the document.	3/9/2007
2	Added section and table for rigid bus ratings. Also removed the section associated with generator rating. This is included in the ratings methodology procedure for generators.	11/1/2007
3	Removed the reference to generators in the "Purpose" section.	6/18/2008
4	Added section on high temperature conductors within the Overhead conductor section II.1.	12/12/08
5	Added section on ratings for 6 inch bus in table in the appendix.	2/25/09
6	Revised transformer section for thermal overload to refer to C57.92 and added series reactors to the procedures.	6/05/09
7	Added IEEE standard references for equipment ratings associated with transformers, switches, circuit breakers, and reactive devices.	6/26/09

AECI's Facility Rating Methodology And Communication.

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I. Purpose / Introduction

The purpose of this document is to ensure that Facility Ratings used in planning and operation of AECI's Bulk Electric System (BES) are determined based on an established methodology.

This rating criteria applies to transmission circuits on AECI's and its member owner's transmission system operated at 69kV and above, and specifies how to develop the maximum rating of each element of a transmission circuit.

This rating criteria specifically addresses overhead conductors, power transformers, switches, wave traps, current transformers, circuit breakers, relays and protective equipment, and series and shunt reactive elements. Where appropriate normal, emergency, short term emergency, and seasonal ratings are developed. Short term emergency ratings are only used when an operating guide is available to reduce the circuit loading to within the emergency rating. This discussion also extends the overhead conductor section to include bus conductors.

A summary page of rating for equipment used in transmission other than conductors is provided in Appendix F.

I.1 Limiting Factor

The overall rating of a transmission circuit will be established by the most limiting device within that circuit. In the case of a transmission circuit that interconnects with another utility, AECI shall coordinate the overall rating of that circuit with the utility involved. The overall transmission circuit rating shall be the lower of either AECI's equipment rating or the equipment rating of the interconnecting utility.

II. Facility Rating Methodology

II.1 Overhead Conductors

AECI's rating criteria for overhead conductors is based on IEEE std 738-1993, IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors. Associated will use the BASIC program provided with IEEE std 738-1993, which requires input of the variables discussed below. A table of frequently used Associated conductor sizes and their ratings as based on this criteria is in Appendix A.

Conductor Temperature

All transmission lines are designed such that an acceptable ground clearance is maintained at a certain design temperature according to the construction standards at the time. Associated's, and its members', lines have been designed to conform to REA standards. Historically REA's required clearances have been more restrictive than those required by NESC, which allows the conductor to operate at a higher temperature than originally designed for, and still comply with NESC standards. Thus, unless Associated has specific information to the contrary, a default temperature of 167°F (75°C) will be used to calculate both normal and emergency ratings for transmission lines even though some of the older transmission lines were designed for operation at 120°F(49°C). If a field check determines a line can operate at higher than 75°C that temperature will be used to determine the normal and emergency rating for the line.

Conductors used within a substation for bus work, where the conductor is under tension, will be rated the same as overhead transmission line conductors using a maximum conductor temperature of 100°C unless specific design information to the contrary is available. Conductors used for jumpers, or other short untensioned spans where mechanical strength is not a concern, will be rated at a maximum conductor temperature of 140°C.

Wire manufacturers have begun producing a new class of high-temperature, low sag conductor that can operate at temperatures up to 250°C. Associated has begun using these conductors on select transmission lines. The rating for these line sections will be based on the specific conductor temperature that the line design for that specific application is based on. The ampacities for these conductors will be entered into the database on a case-by-case basis based on the conductor manufacturer's design data and good engineering judgment. The overall transmission circuit rating will be based on the most limiting element as discussed in Section I.1 above.

Conductor Properties

Resistance/Diameter - The conductor properties of *resistance* and *diameter* will be obtained from the EPRI Transmission Line Reference Book 345kV and Above. For those conductors not listed in the EPRI book, an appropriate reference will be used.

Radiation Constants - The two radiative properties of conductors are solar absorptivity and infrared emissivity. With certain aspects of a line not known, selection of these two variables can be highly subjective.

The *Solar Absorptivity* coefficient represents the fraction of incident solar radiant

energy that is absorbed by the conductor surface. The solar absorptivity coefficient varies between about 0.2 to about 0.9, with higher values indicating that more solar energy is being absorbed by the conductor. As a conductor ages, the solar absorptivity, or the amount of solar energy absorbed by the conductor increases, which decreases the MVA rating of the conductor.

The *Infrared Emissivity* coefficient represents the ratio of radiant energy emitted by the conductor surface to the infrared radiant energy emitted by a blackbody at the same temperature, and can vary between about 0.2 to about 0.9. As a conductor ages, the infrared emissivity, or ability of the conductor to radiate heat energy to its surroundings increases, which increases the MVA rating of the conductor. According to IEEE Std 738-1993 the absorptivity generally stays higher than the emissivity over the life of a conductor. Thus, to eliminate the need to update conductor ratings annually, and to provide a conservative value for conductor ratings, AECL has chosen to use 0.9 for absorptivity and 0.85 for emissivity for all conductors.

Geographic Location

Elevation - *Elevation* of a conductor above sea level is another variable used in the calculation of conductor capacity. The elevation of a conductor affects the amount of solar energy absorbed and the amount of energy given off to the air around it. The results of a sensitivity analysis (Appendix B, Table B1) show this effect is small compared to many of the other variables, therefore attempts to acquire elevations for specific transmission lines will not be made. A default elevation of 1000 feet as being a fairly representative elevation for Missouri, will be used for all conductors.

Latitude - The *latitude* of a conductor affects the amount of solar energy absorbed by a transmission line. A default latitude of 38 degrees, the approximate center latitude of Missouri, will be used for all lines. Table B2 in Appendix B shows the effects of latitude on a conductors' current capacity.

Direction and Local Sun Time - The *direction* of a conductor, classified as either North-South or East-West by the IEEE program, describes the general direction of a transmission line. *Local Sun time* describes the overhead position of the sun. These two variables separately and together effect, but not to a large degree, the amount of solar energy absorbed by the conductor. A direction of North-South is recommended as the default for Associated and member G&T transmission lines. This reduces the effect of Local Sun Time on the conductor's capacity, which is given a default value of 12 noon. Table B2 in Appendix B shows the effects of direction and local sun time on a conductors' current capacity.

Atmosphere - *Atmospheric conditions* also have an effect on the rating of a conductor. The IEEE program options are clear or industrial atmosphere. An industrial atmosphere will increase the rating of a transmission line due to decreased solar absorption. Since the majority of Associated's transmission lines are located in rural areas, clear atmosphere is recommended as the default for Associated and member G&T transmission lines.

Weather Conditions

Ambient Temperature - *Ambient temperature* is an important factor in calculating the capacity of a conductor. It represents the maximum seasonal temperature a transmission line may experience and is used as the basis seasonal ratings.

The summer *maximum ambient temperature* is calculated by averaging the top 1% of the hourly temperature readings, for June through September, for the most recently available five year period. The winter *maximum ambient temperature* is calculated by averaging the top 1% of the hourly temperature readings, for December through March, for the most recently available five year period. This was done for Columbia, Kansas City, St. Louis and Springfield for the years 1991 through 1995. An *off-peak ambient temperature* was also calculated in this same manner for the combination of the months April, May, October and November. Appendix C lists these averages in tabular form.

The highest calculated ambient air temperature in Appendix C, 99.8°F, was at Kansas City and will be rounded up to 100°F (37.8°C) and used for the summer maximum ambient temperature. The highest calculated ambient air temperature for the winter period at Kansas City is 76.3°F and will be rounded up to 77°F (25°C). For the off-peak period, the highest calculated ambient air temperature at Kansas City is 86.1°F and will be rounded up to 87°F (30.6°C).

Wind Speed - Wind Speed is assumed to be 2 ft/sec in a direction perpendicular to the conductor. This is a generally accepted industry standard.

Short-Term Conductor Ratings

IEEE Std 738-1993 includes a methodology for calculating transient conductor ratings based on a step change in current, such as what occurs following a contingency. AECI develops its short-term conductor ratings based on this methodology assuming a 70% pre-contingency loading on the conductor followed by a 120% post-contingency loading. The BASIC program within the referenced IEEE Standard is used to calculate the available time until the conductor reaches the conductor temperature that the continuous rating is based on. A table is included in Appendix E showing the times available for typical conductors used on AECI's system.

Rigid Bus Conductor Ratings

The ampacity of rigid bus bar conductors within substations shall be based on the equations contained in Annex C of IEEE Std 605-1998. In the case of round pipe type bus conductors Std 605 equations are consistent with those used for overhead transmission line conductors discussed above and thus their ampacities can be calculated with the same equations. For other bus conductor shapes the equations in Std 605 shall be used. The equation variables pertaining to weather and geographic location shall be the same as discussed above for overhead transmission conductors. The resistance of the particular bus conductor alloy shall be derived from the equations in C.4.4 of Std 605. The absorptivity and emissivity constants shall each be assumed to be 0.5 as suggested in Std 605 as being representative of aluminum conductors after extended outdoor exposure. According to Std 605 aluminum alloy and copper conductors can be operated at 90° C continuously without appreciable loss of strength and can be operated at 100° C under emergency conditions with some annealing. Based on this AECI shall use 90° C for its normal rating and 100° C for its 2 hour emergency rating. A table is included in Appendix A.

II.2 Power Transformers

Associated's Power Transformer ratings are based on IEEE C57.12.00-1980 and IEEE C57.92-1981

Associated has not yet developed an acceptable loss of life criteria for power transformers and will use the highest nameplate rating as both the normal and emergency rating. Power transformers are rated based on average daily temperatures due to their relatively high thermal inertia constants. In a manner similar to the daily maximum temperature selections under the conductor rating sections, daily averages for Associated's service area have been established for three seasons; summer 32° C, spring/fall 25° C, and winter 18° C. Associated has developed a higher winter season rating for its transformers based on ANSI Standard C57.92-1981. As per the capability tables in C57.92 an OA/FOA/FOA transformer, at an average ambient temperature of 18° C, can carry 115% of its maximum nameplate rating for 8 hours with no loss of life. Using the same tables an OA/FA/FA transformer has a 117% capability. For the sake of consistency Associated has adopted the 115% multiplier to establish the winter rating for all transformers.

Associated will use ANSI/IEEE Standard C57.92-1981 Table 3 to determine the short term ratings for emergency conditions for transformers that have a low side voltage greater than 100kV. The % loss of life noted within the table shall be "Normal".

II.3 Switches

Associated's High-Voltage Switch ratings are based on IEEE C37.30-1971, IEEE C37.32-1972 and IEEE C37.37-1979

Associated will use the manufacturers continuous nameplate rating for both normal and emergency ratings, for all seasons unless specific circumstances arise that may require a higher rating to be developed. The IEEE Standards C37.30-1971 and C37.37-1979 will be used as the basis for these higher ratings.

Associated has developed short term, 15 minute, ratings for its disconnect switches to be used when an operating guide exists to return the transmission circuit loading to within its maximum continuous rating. These short term ratings will be based on the most limiting switch part class as identified in the C37.37 loadability guide. Based on C37.30 requirements, the temperature rise of a switch part due to current flow is determined by the square of the current increase:

$$(\text{lactual}/\text{lrated})^2 = \text{Temperature Rise}/\text{Rated Temperature Rise}$$

The standard also states that at a constant current, the temperature approaches its steady state value at an exponential rate and suggests 30 minutes as a conservative switch part time constant. In equation form then a short time rating multiplier can be established by:

$$(1/\text{RatTempRise} * (\text{AvailTempRise}/(1 - e^{-t/T}) + (\text{TempMax} - \text{AmbTemp}))),^{0.5} \text{ where}$$

RatTempRise = Switch Part Rated Temperature Rise
AvailTempRise = RatTempRise less actual operating temperature

t = emergency loading time interval desired in minutes
T = switch part time constant (30 minutes)
TempMax= Switch part maximum operating temperature
AmbTemp = ambient temperature

Using these equations AECl has established the 15 minute short term multipliers for summer as 152%, spring/fall as 162%, and winter as 167%. These are also shown in Appendix E.

II.4 Wave Traps

Associated's transmission system has two types of wave traps commonly in use; the older air-core type, covered by ANSI Standard C93.3-1981, Requirements for Power-Line Carrier Line Traps, and a newer epoxy-encapsulated type, which are not covered by an ANSI/IEEE standard. The loadability guidelines provided by Trench Electric will be used for epoxy-encapsulated wave traps.

A graphical representation of the loadability factors is in Appendix D. A wave trap's rating is simply the nameplate rating multiplied by the appropriate loadability factor. The emergency current rating represents a level of current that should be maintained for no longer than four hours per load cycle, with the wave trap loading being at or below the normal current loading for at least two hours before the emergency load cycle occurs.

Associated's normal and emergency rating for air-core wave traps will be based on the '4 Hour Emergency' loadability factors from the graph in Appendix D. For a summer rating based on a 100°F ambient, the factor will be 1.11 and likewise, for a winter rating based on a 77°F ambient, the factor will be 1.14. Associated will use the normal rating loadability factors supplied by Trench Electric, for normal and emergency rating of epoxy encapsulated wave traps. For a summer rating on a 100°F ambient, the factor will be 1.02 and likewise, for a winter rating on a 77°F ambient, the factor will be 1.09.

Associated has developed short term, 15 minute, ratings for its wave traps to be used when an operating guide exists to return the transmission circuit loading to within its maximum continuous rating. These short term ratings are developed with the same curves and loadability information discussed above. From this information AECl has established the 15 minute short term multipliers as follows:

Air core traps

summer--141%, spring/fall--142%, and winter--144%

Epoxy traps

summer—109%, spring/fall—120%, and winter—128%.

These are also shown in Appendix E.

II.5 Current Transformers

The two types of current transformers are the separately mounted type or the bushing type. The basis of this current transformer criterion is ANSI/IEEE C57.13-1978, IEEE Standard Requirements for Instrument Transformers.

Separately mounted CTs will have normal and emergency ratings based on the primary current rating for the ratio being used and the average ambient adjusted Continuous-Thermal-Current rating factor supplied by the specific current transformer manufacturer.

Rating of bushing type CTs is dependent upon the environment within the device they are mounted. Associated will use the rating formulas below based on a Westinghouse Electric technical paper entitled "Memorandum on Thermal Current Characteristics of Current Transformers Used with Power Circuit Breakers and Power Transformers."

$$\text{Rating Factor} = \text{R.F.} = (I_{pa}/I_{ct})^{1/2} \qquad \text{CT current rating} = \text{R.F.} * I_{ct}$$

or

$$\text{CT current rating} = (I_{pa} * I_{ct})^{1/2}$$

where

I_{pa} = Power apparatus continuous current rating (amps)

I_{ct} = Primary current rating of bushing current transformer ratio used (amps)

The results calculated from this equation should be so limited that the maximum rating factor does not exceed 2.0 and that the continuous current rating of the breaker or the rated current of the power transformer is not exceeded.

The Westinghouse technical paper referenced above states that short term emergency ratings as permitted by IEEE C37.010, can be applied to bushing CTs. On this basis, AECI will use the short term multipliers developed in the Circuit Breaker section below, for bushing CTs.

II.6 Circuit Breakers

Associated's High-Voltage Circuit Breaker ratings are based on IEEE C37.06-1979 and IEEE C37.010-1979

Associated will use the manufacturers continuous nameplate rating for both normal and emergency ratings, for all seasons, unless specific circumstances arise that may require a higher rating to be developed. The IEEE Standard C37.010-1979 will be used as the basis for these higher ratings.

Associated has developed short term, 15 minute, ratings for its circuit breakers to be used when an operating guide exists to return the transmission circuit loading to within its maximum continuous rating. These short term ratings are developed with the same equations utilized above for disconnect switches except, as per C37.010, the temperature rise of breaker parts is proportional to the 1.8 power of the current rise. Using these equations AECI has established the 15 minute short term multipliers for summer as 148%, spring/fall as 151%, and winter as 153%. These are also shown in Appendix E.

II.7 Relays and Protective Equipment

Relays can impose limits on transmission power flow in two ways. First, the current flow through the relay, as determined by the transmission circuit current flow in combination with the current transformer ratio chosen, could exceed the relays' internal thermal capabilities. Secondly, the relay distance setting could initiate an undesired line trip during abnormally high transmission circuit power flows. AECI's transmission circuit ratings, or applicable current transformer ratios chosen, shall be such that any underlying relays thermal capability is not exceeded. Additionally, to prevent inadvertent clearing, the emergency transmission circuit ratings shall be no higher than 2/3 of any applicable distance relay MVA pickup value calculated at 0.85 per unit of nominal voltage at a line phase angle of 30 degrees.

II.8 Series and Shunt Reactive Devices.

Series reactors on AECI's system are rated according to the manufacturer's continuous nameplate rating for the summer season. Series reactors, like power transformers, are rated based on average daily temperatures. For spring/fall and winter seasons the multipliers in ANSI C57.99-1965, Table 1, are used to adjust the manufacturer's nameplate rating to the applicable seasonal average daily temperature. See Section II.2 above. Series reactors are specified, designed and applied according to IEEE C57.16-1996.

Short term emergency ratings for series reactors are based on the applicable ANSI C57.99-1965, Table 2 to give normal life expectancy, for the time period desired. Since Table 2 of C57.99 is for summer average daily temperatures, the spring/fall and winter short-term emergency ratings will use the multipliers of Table 1 to adjust the short-term rating to the applicable season.

Shunt reactors are specified, designed and applied according to IEEE C57.21-1981.

Shunt capacitors are specified, designed and applied according to IEEE 1036-1992.

III. Communication of Facility Methodology

This document shall be posted on the AECI Public OASIS domain for review by the Reliability Coordinator, Transmission Operators, Transmission Planners and Planning Authorities that have responsibilities within the AECI BES area. It is also available on the AECI server for Engineering and Operations department to review. It is a departmental requirement that each planning engineer ensure that these methodologies are followed when preparing engineering studies for AECI and its Member-Owner Cooperatives.

IV. Handling of Comments from Other Entities

AECI will provide a written response within 45 days to any written comments provided from an RC, TO, TP, or PA associated with this document.

AECI THERMAL CONDUCTOR RATINGS

CONDUCTOR	CONDITION	Amps-- MVA Rating per Conductor at Specific Voltages --						
		per Conductor	-- Voltages in kV --					
			34.5	69	138	161	345	500
105.7 (1/0), ACSR 6/1								
	Summer Normal	209	13	25	50	58	125	181
	Summer Emergency	279	17	33	67	78	167	241
	Winter Normal	251	15	30	60	70	150	217
	Winter Emergency	308	18	37	74	86	184	267
	Off-Peak Normal	234	14	28	56	65	140	202
	Off-Peak Emergency	296	18	35	71	83	177	256
105.7 (1/0), Copper								
	Summer Normal	260	16	31	62	72	155	225
	Summer Emergency	348	21	42	83	97	208	301
	Winter Normal	311	19	37	74	87	186	269
	Winter Emergency	385	23	46	92	107	230	333
	Off-Peak Normal	290	17	35	69	81	173	251
	Off-Peak Emergency	369	22	44	88	103	221	320
133 (2/0), ACSR 6/1								
	Summer Normal	229	14	27	55	64	137	198
	Summer Emergency	301	18	36	72	84	180	261
	Winter Normal	274	16	33	66	76	164	238
	Winter Emergency	333	20	40	80	93	199	288
	Off-Peak Normal	256	15	31	61	71	153	221
	Off-Peak Emergency	320	19	38	76	89	191	277
133.1 (2/0), Copper								
	Summer Normal	300	18	36	72	84	179	260
	Summer Emergency	404	24	48	97	113	241	350
	Winter Normal	360	21	43	86	100	215	312
	Winter Emergency	447	27	53	107	125	267	387
	Off-Peak Normal	335	20	40	80	94	200	290
	Off-Peak Emergency	429	26	51	103	120	256	371
167.7 (3/0), ACSR 6/1								
	Summer Normal	261	16	31	62	73	156	226
	Summer Emergency	344	21	41	82	96	206	298
	Winter Normal	314	19	38	75	88	188	272
	Winter Emergency	381	23	46	91	106	228	330
	Off-Peak Normal	292	17	35	70	82	175	253
	Off-Peak Emergency	366	22	44	87	102	219	317

AECI THERMAL CONDUCTOR RATINGS

CONDUCTOR	CONDITION	Amps-- MVA Rating per Conductor at Specific Voltages --						
		per Conductor	-- Voltages in kV --					
			34.5	69	138	161	345	500
211.3, ACSR 12/7								
	Summer Normal	294	18	35	70	82	176	254
	Summer Emergency	383	23	46	91	107	229	331
	Winter Normal	355	21	42	85	99	212	308
	Winter Emergency	424	25	51	101	118	253	367
	Off-Peak Normal	330	20	39	79	92	197	286
	Off-Peak Emergency	407	24	49	97	113	243	352
211.6 (4/0), ACSR 6/1								
	Summer Normal	297	18	36	71	83	178	257
	Summer Emergency	393	23	47	94	109	235	340
	Winter Normal	358	21	43	86	100	214	310
	Winter Emergency	435	26	52	104	121	260	376
	Off-Peak Normal	333	20	40	80	93	199	289
	Off-Peak Emergency	417	25	50	100	116	249	361
211.6 (4/0), Copper								
	Summer Normal	400	24	48	96	112	239	347
	Summer Emergency	544	33	65	130	152	325	471
	Winter Normal	482	29	58	115	134	288	417
	Winter Emergency	603	36	72	144	168	360	522
	Off-Peak Normal	448	27	54	107	125	268	388
	Off-Peak Emergency	578	35	69	138	161	346	501
266.8, ACSR 26/7								
	Summer Normal	371	22	44	89	103	222	321
	Summer Emergency	508	30	61	121	142	303	440
	Winter Normal	449	27	54	107	125	268	388
	Winter Emergency	563	34	67	134	157	336	487
	Off-Peak Normal	417	25	50	100	116	249	361
	Off-Peak Emergency	540	32	64	129	150	322	467
335.6 (2-3/0), ACSR								
	Summer Normal	414	25	49	99	115	247	358
	Summer Emergency	557	33	67	133	155	333	483
	Winter Normal	503	30	60	120	140	300	435
	Winter Emergency	618	37	74	148	172	369	535
	Off-Peak Normal	466	28	56	111	130	279	404
	Off-Peak Emergency	593	35	71	142	165	354	513

AECI THERMAL CONDUCTOR RATINGS

CONDUCTOR	CONDITION	Amps-- MVA Rating per Conductor at Specific Voltages --						
		per Conductor	-- Voltages in kV --					
			34.5	69	138	161	345	500
336.4, ACSR 26/7								
	Summer Normal	428	26	51	102	119	256	371
	Summer Emergency	589	35	70	141	164	352	510
	Winter Normal	519	31	62	124	145	310	449
	Winter Emergency	653	39	78	156	182	390	565
	Off-Peak Normal	482	29	58	115	134	288	417
	Off-Peak Emergency	626	37	75	150	175	374	542
477, ACSR 26/7								
	Summer Normal	531	32	64	127	148	318	460
	Summer Emergency	737	44	88	176	206	441	639
	Winter Normal	646	39	77	154	180	386	560
	Winter Emergency	818	49	98	195	228	489	708
	Off-Peak Normal	600	36	72	143	167	358	519
	Off-Peak Emergency	784	47	94	187	219	469	679
556.5, ACSR 26/7								
	Summer Normal	585	35	70	140	163	349	506
	Summer Emergency	815	49	97	195	227	487	705
	Winter Normal	712	43	85	170	199	426	617
	Winter Emergency	904	54	108	216	252	540	783
	Off-Peak Normal	660	39	79	158	184	395	572
	Off-Peak Emergency	866	52	104	207	242	518	750
636, ACSR 18/1								
	Summer Normal	627	37	75	150	175	375	543
	Summer Emergency	875	52	105	209	244	523	758
	Winter Normal	765	46	91	183	213	457	662
	Winter Emergency	971	58	116	232	271	580	841
	Off-Peak Normal	709	42	85	169	198	424	614
	Off-Peak Emergency	931	56	111	223	260	556	806
636, ACSR 26/7								
	Summer Normal	635	38	76	152	177	379	550
	Summer Emergency	888	53	106	212	247	530	769
	Winter Normal	775	46	93	185	216	463	671
	Winter Emergency	985	59	118	235	275	589	853
	Off-Peak Normal	718	43	86	172	200	429	622
	Off-Peak Emergency	944	56	113	226	263	564	818

AECI THERMAL CONDUCTOR RATINGS

CONDUCTOR	CONDITION	Amps-- MVA Rating per Conductor at Specific Voltages --						
		per Conductor	-- Voltages in kV --					
			34.5	69	138	161	345	500
795, ACSR 26/7								
	Summer Normal	728	44	87	174	203	435	631
	Summer Emergency	1025	61	122	245	286	612	887
	Winter Normal	891	53	107	213	249	533	772
	Winter Emergency	1138	68	136	272	317	680	985
	Off-Peak Normal	825	49	99	197	230	493	714
	Off-Peak Emergency	1091	65	130	261	304	652	944
954, ACSR 54/7								
	Summer Normal	810	48	97	194	226	484	702
	Summer Emergency	1146	68	137	274	319	685	992
	Winter Normal	994	59	119	238	277	594	861
	Winter Emergency	1272	76	152	304	355	760	1102
	Off-Peak Normal	919	55	110	220	256	549	796
	Off-Peak Emergency	1219	73	146	291	340	729	1056
954, ACSR 54/37								
	Summer Normal	930	56	111	222	259	556	806
	Summer Emergency	1348	81	161	322	376	806	1168
	Winter Normal	1155	69	138	276	322	690	1000
	Winter Emergency	1500	90	179	359	418	897	1299
	Off-Peak Normal	1064	64	127	254	297	636	921
	Off-Peak Emergency	1437	86	172	343	401	859	1244
1192.5, ACSR 54/19								
	Summer Normal	937	56	112	224	261	560	812
	Summer Emergency	1336	80	160	319	372	798	1157
	Winter Normal	1154	69	138	276	322	690	999
	Winter Emergency	1484	89	177	355	414	887	1285
	Off-Peak Normal	1066	64	127	255	297	637	923
	Off-Peak Emergency	1422	85	170	340	397	850	1232
1272, ACSR 45/7								
	Summer Normal	955	57	114	228	266	571	827
	Summer Emergency	1362	81	163	326	380	814	1180
	Winter Normal	1176	70	141	281	328	703	1018
	Winter Emergency	1514	90	181	362	422	904	1311
	Off-Peak Normal	1086	65	130	260	303	649	941
	Off-Peak Emergency	1450	87	173	347	404	867	1256

AECI THERMAL CONDUCTOR RATINGS

CONDUCTOR	CONDITION	Amps-- MVA Rating per Conductor at Specific Voltages --						
		per Conductor	-- Voltages in kV --					
			34.5	69	138	161	345	500
1590, ACSR 45/7								
	Summer Normal	1089	65	130	260	304	651	943
	Summer Emergency	1566	94	187	374	437	936	1357
	Winter Normal	1346	80	161	322	375	804	1165
	Winter Emergency	1742	104	208	416	486	1041	1508
	Off-Peak Normal	1242	74	148	297	346	742	1076
	Off-Peak Emergency	1668	100	199	399	465	997	1445
1590, ACSR 54/19								
	Summer Normal	1113	67	133	266	310	665	964
	Summer Emergency	1603	96	192	383	447	958	1388
	Winter Normal	1376	82	164	329	384	822	1192
	Winter Emergency	1782	106	213	426	497	1065	1543
	Off-Peak Normal	1270	76	152	303	354	759	1100
	Off-Peak Emergency	1707	102	204	408	476	1020	1479
2156, ACSR 84/19								
	Summer Normal	1313	78	157	314	366	785	1137
	Summer Emergency	1913	114	229	457	533	1143	1657
	Winter Normal	1631	97	195	390	455	975	1412
	Winter Emergency	2129	127	254	509	594	1272	1844
	Off-Peak Normal	1503	90	180	359	419	898	1301
	Off-Peak Emergency	2039	122	244	487	569	1218	1766

Assumptions

Summer Ambient Temp = 100 F	Coef of Emiss = 0.85	75 C/100 C Line Design
Temp		
Winter Ambient Temp = 77 F	Coef of Absorp = 0.90	Elevation = 1000 ft
Off-Peak Ambient Temp = 87 F	Latitude = 38 deg	Clear Atmosphere
Wind Speed = 2 ft/sec	12 pm Local Sun Time	

**ASSOCIATED ELECTRIC COOPERATIVE
RATINGS OF TYPICAL RIGID BUS CONDUCTORS**
Schedule 40 Aluminum Pipe Conductors 6063-T6 Alloy

Std. Pipe Size, In.	Summer Ratings		Spring/Fall Ratings		Winter Ratings	
	Normal	Emerg	Normal	Emerg	Normal	Emerg
2	1409	1563	1546	1684	1602	1734
2 1/2	1877	2084	2028	2218	2136	2315
3	2285	2544	2471	2708	2604	2826
3 1/2	2615	2916	2830	3105	2983	3241
4	2955	3300	3200	3516	3374	3670
5	3683	4125	3992	4396	4212	4591
6	4466	5007	4840	5334	5107	5571

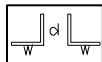
Schedule 80 Aluminum Pipe Conductors 6063-T6 Alloy

Std. Pipe Size, In.	Summer Ratings		Spring/Fall Ratings		Winter Ratings	
	Normal	Emerg	Normal	Emerg	Normal	Emerg
2	1639	1816	1769	1932	1863	2015
2 1/2	2152	2391	2326	2544	2450	2654
3	2648	2948	2864	3139	3018	3276
3 1/2	3049	3400	3299	3620	3478	3779
4	3458	3862	3744	4113	3948	4295
5	4345	4867	4710	5186	4969	5416
6	5382	6034	5833	6428	6155	6714



Single Angle Conductors 6061-T6 Alloy

d	w	t	Summer Ratings		Spring/Fall Ratings		Winter Ratings	
			Normal	Emerg	Normal	Emerg	Normal	Emerg
3	3	3/8	2070	2291	2231	2434	2346	2536
4	3	3/8	2366	2619	2548	2780	2678	2896
4	4	3/8	2582	2870	2787	3050	2933	3180
5	3 1/2	3/8	2703	2968	2912	3151	3023	3282
6	4	3/8	3136	3483	3380	3698	3507	3853

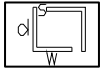


Double Angle Back-Back Conductors 6061-T6 Alloy

d	w	t	Summer Ratings		Spring/Fall Ratings		Winter Ratings	
			Normal	Emerg	Normal	Emerg	Normal	Emerg
3	3	3/8	4196	4633	4514	4915	4741	5118
4	3	3/8	4810	5306	5169	5624	5424	5853
4	4	3/8	5245	5810	5649	6167	5936	6424
5	3 1/2	3/8	5504	6022	5915	6382	6208	6642
6	4	3/8	6397	7076	6876	7499	7217	7804

Appendix A

Report – Rigid Bus



Double Angle Boxed Conductors 6061-T6 Alloy

d	w	s	Summer Ratings		Spring/Fall Ratings		Winter Ratings	
			Normal	Emerg	Normal	Emerg	Normal	Emerg
3	3	1	3735	4125	4026	4386	4236	4576
4	3	1	4259	4702	4589	4999	4827	5215
4	4	1	4675	5175	5045	5507	5312	5748
5	3 1/2	1 1/2	4942	5410	5324	5749	5599	5996
6	4	2	5810	6426	6257	6828	6579	7119

Assumptions

Summer amb.=	100 F	Elev.=	1000'	Emiss.=	0.5
Spr/Fall amb.=	87 F	Latitude=	38 deg N.	Absorb.=	0.5
Winter amb.=	77 F	Atmos.=	Clear	Nor. Temp=	90.0 C
Wind Speed =	2ft/sec	Sun time=	12 pm	Emer. Temp=	100.0 C

795 mcm ACSR Conductor

Table B1 - Elevation Sensitivity Analysis Results

		Winter Amps	Summer Amps
		Norm/Emer	Norm/Emer
Local Sun time = 12pm	0	899/1146	735/1032
Latitude = 38 Deg	500	892/1140	728/1026
East - West line direction	1000	885/1134	721/1020
	1500	879/1127	714/1014
	2000	872/1121	707/1008

Table B2 - Latitude, Direction and Local Sun Time Sensitivity Analysis Results

		Winter Amps				Summer Amps			
		Latitude (degrees)				Latitude (degrees)			
		37	38	39	40	37	38	39	40
		Norm/Eme	Norm/Em	Norm/Eme	Norm/Eme	Norm/Eme	Norm/Eme	Norm/Eme	Norm/Eme
		r	er	r	r	r	r	r	r
Elevation = 1000ft East - West line direction	10	908/1150	908/1150	908/1150	908/1150	748/1038	748/1038	748/1038	748/1038
	11	891/1137	891/1137	891/1138	891/1138	727/1024	727/1024	728/1025	728/1025
	12	885/1133	885/1134	886/1134	886/1134	721/1020	721/1020	721/1020	721/1020
	1	891/1137	891/1137	891/1138	891/1138	727/1024	727/1024	728/1025	728/1025
	2	908/1150	908/1150	908/1150	908/1150	748/1038	748/1038	748/1038	749/1038
		Winter Amps				Summer Amps			
		Latitude (degrees)				Latitude (degrees)			
		37	38	39	40	37	38	39	40
		Norm/Eme	Norm/Eme	Norm/Eme	Norm/Eme	Norm/Eme	Norm/Eme	Norm/Eme	Norm/Eme
		r	r	r	r	r	r	r	r
Elevation = 1000ft North-South line direction	10	892/1138	892/1139	893/1139	894/1140	729/1025	729/1026	730/1026	731/1027
	11	895/1140	896/1141	896/1141	897/1142	732/1028	733/1028	734/1029	735/1030
	12	891/1137	891/1138	892/1138	893/1139	727/1024	728/1025	729/1026	730/1026
	1	895/1140	896/1141	896/1141	897/1142	732/1028	733/1028	734/1029	735/1030
	2	892/1138	892/1139	893/1139	894/1139	729/1025	729/1026	730/1026	731/1027

Summer Ambient Temp = 100 F
 Winter Ambient Temp = 77 F
 Wind speed = 2 ft/s
 Norm cond temp = 75 C

Emerg cond temp = 100 C
 Clear Atmosphere
 Coef of Solar Absorption = 0.9
 Coef of Infrared Emissivity = 0.85

Appendix C: Maximum Temperatures

Calculated Maximum Summer Ambient Temperatures

(June through September)

Year	Columbia	Kansas City	Springfield	St. Louis
1991	97.7	99.8	97.4	98.9
1992	91.2	89.8	89.9	94.2
1993	93.0	95.2	94.8	94.8
1994	94.1	94.0	94.1	95.1
1995	95.4	96.1	97.0	97.4
Maximum	97.7	99.8	97.4	98.9

Calculated Maximum Winter Ambient Temperatures

(December through March)

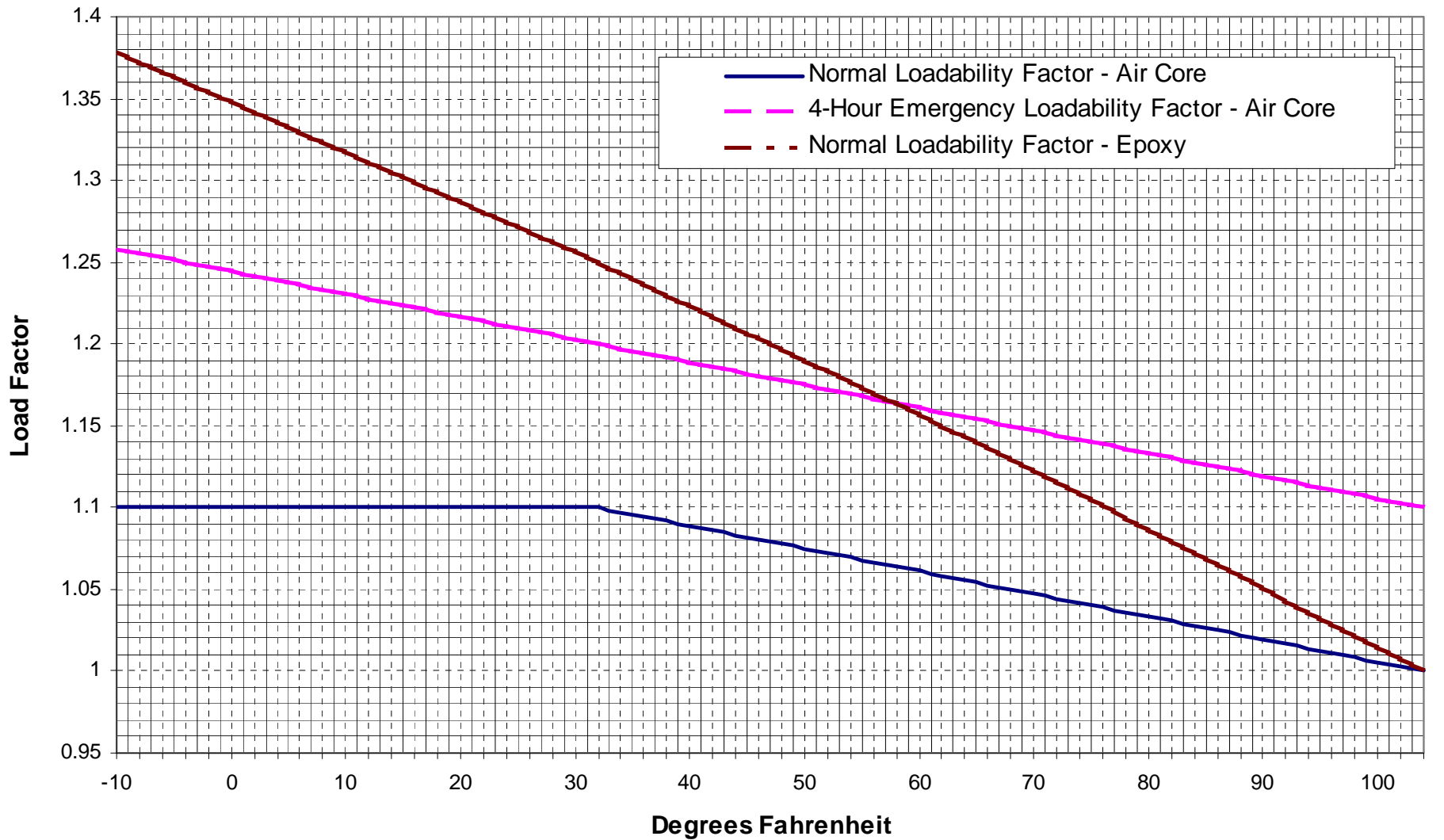
Year	Columbia	Kansas City	Springfield	St. Louis
1991	77.9	75.9	74.9	80.7
1992	74.7	73.1	73.1	74.6
1993	71.5	65.6	72.5	70.1
1994	74.9	75.0	75.1	75.3
1995	75.9	76.3	78.7	76.2
Maximum	77.9	76.3	78.7	80.7

Calculated Maximum Off-Peak Ambient Temperatures

(April, May, October and November)

Year	Columbia	Kansas City	Springfield	St. Louis
1991	86.8	85.6	84.6	90.1
1992	83.1	83.0	82.1	84.8
1993	82.0	82.0	81.0	83.8
1994	83.6	86.1	84.4	85.3
1995	83.1	82.7	84.1	84.5
Maximum	86.8	86.1	84.6	90.1

Appendix D - Wavetrapped Loadability Factor vs Ambient Temperature



Appendix E - Short Term Loading Guidelines

Short Term Loading Times for Common AECI Conductors						
SEASONAL -- 70% PRECONTINGENCY LOADING FOLLOWED BY 120% POST CONTINGENCY LOADING						
Conductor Name	MCM	Type	Stranding	Time in minutes to reach max. conductor temperature		
				Summer	Spring/Fall	Winter
Falcon	1590	ACSR	54/19	12.8	13.1	13.4
Lapwing	1590	ACSR	45/7	12.1	12.4	12.6
Rio Grande	1533.3	ACSS/TW	39/19	17.9	12.1	12.4
River Cross	1351.5	ACSS/TW	36/37	18.5	18.8	19.2
Grackle	1192.5	ACSR	54/19	10.6	11.0	11.2
Cardinal	954	ACSR	54/7	9.2	9.5	9.7
Drake	795	ACSR	26/7	8.4	8.6	8.8
Grosbeak	636	ACSR	26/7	7.2	7.4	7.6
Dove	556.5	ACSR	26/7	6.6	6.8	6.9
Hawk	477	ACSR	26/7	6.0	6.1	6.2

AECI Short Term Load Guide for Disconnect Switches						
SEASONAL -- 70% PRECONTINGENCY LOADING						
AECI Seasons	For most limiting case		70% Initial	Max Ambient Temp	Continuous Rating Factors	Minute Rating Factors ²
	Max Switch Part Temp	Max Switch Part Temp Rise	Avail Switch Part Temp Rise			
Summer	70	30	15.3	40	100%	152%
Spring/Fall	70	30	15.3	30	115%	162%
Winter	70	30	15.3	25	122%	167%

AECI Short Term Load Guide for Power Circuit Breakers						
SEASONAL -- 70% PRECONTINGENCY LOADING						
AECI Seasons	For most limiting case		70% Initial	Max Ambient Temp	Continuous Rating Factors	Minute Rating Factors ²
	Limit Break Part Temp	Limit Break Part Temp Rise	Avail Break Part Temp Rise			
Summer	150	110	52.1	40	100%	148%
Spring/Fall	150	110	52.1	30	104%	151%
Winter	150	110	52.1	25	107%	153%

Appendix F - Component Rating Summary for Associated and Member G&T Systems

<u>COMPONENT</u>	<u>NORMAL RATING</u>	<u>EMERGENCY RATING</u>
<u>Power Transformers</u>		
Summer	Highest Nameplate Rating	Highest Nameplate Rating
Winter	Highest Nameplate Rating*1.15	Highest Nameplate Rating*1.15
<u>Switches</u>		
Summer & Winter	Continuous Nameplate Rating	Continuous Nameplate Rating
<u>Wave Traps</u>		
Epoxy Encapsulated		
Summer	Nameplate Rating*1.02	Nameplate Rating*1.02
Winter	Nameplate Rating*1.09	Nameplate Rating*1.09
Air-Core		
Summer	Nameplate Rating*1.11	Nameplate Rating*1.11
Winter	Nameplate Rating*1.14	Nameplate Rating*1.14
<u>Current Transformers</u>		
Separately Mounted		
Summer & Winter	Nameplate Rating*CT Specific rating factor	
Bushing Type		
Summer & Winter	$(\text{Device Continuous Rating} * \text{Primary Amps of CT Tap})^{1/2}$	
<u>Circuit Breakers</u>		
Summer & Winter	Continuous Nameplate Rating	Continuous Nameplate Rating
<u>Protective Relays</u>		
Summer & Winter	Relay Thermal Rating*CT Ratio	Relay Thermal Rating*CT Ratio
<u>Series & Shunt Reactive Devices</u>		
Summer & Winter	Manufacturer's Nameplate Rating	Manufacturer's Nameplate Rating