Electric Submersible Pump System
Design Data Sheet

Well Data

Company			Field and Well		
Prepared by:			Date		
New Install	Yes / No		Install Date		
Existing Installation Model/Size					
Casing Size	OD	lbs/ft	Liner	OD	lbs/ft
Tubing Size		lbs/ft	Liner - Bottom		Top
Producing Information					
Perforations from	to		Open Hole from		to
Electric Service	Volts		Amps		Hertz

Current Conditions

Static BottomHole Pressure	PSIG at	FT
Flowing BottomHole Pressure	PSIG at	FT
Present Production		
Productivity Index	(Stock Tank BPD or M3PD)	
BottomHole Temperature	(F or C)	
Gas - Oil Ratio (GOR)	SCF/BBL	
Formation Volume Factor	(Reservoir BBL/Stock Tank BBL)	
API Gravity	Well Head Temperature	(ºF OR ºC)
Production - Oil	(BBD or M3PD)	
Production - Water	(BPD or M3PD)	
Production - Gas	(MCFPD or M3PD)	
Producing Wellhead Pressure	PSIG	

Reservoir Data

Water Specific Gravity	Bubble Point Pressure	
Original Reservoir GOR	Original Reservoir Temperature	
Original Reservoir Pressure	PSI @ Feet/Meters	
Oil Viscosity	AT Temperature	(ºF or ºC)
Gas Specific Gravity		

PVT Data

Test	Pressure (PSIA)	OIL FVF (RB/STB)	Gas FVF (RB/SMCF)	Oil Viscosity (CP/SSU)	Solution GOR (SCF/STB)
1					
2					
3					
4					
5					

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Other Problems ***(Please be as specific as possible)***

Sand	Paraffin
Corrosion (Type & Cause)	H2S
Injected Chemicals	Scale
Other Problems	

Equipment Design Specifications

Desired Producing Rate			
Desired Pump Setting Depth	(1) Vertical		(2) Measured
Operating Pump Intake Pressure			
Producing Fluid Level			
Wellhead Pressure	(Tubing)		(Casing)
Free Gas at Pump Intake Pressure			
Casing Vent:	Atmosphere ()	Flowline ()	None()

Additional Comments:

Power and Efficiency Formulas

Power Calculations

Pump Output H.P. (Hydraulic H.P..) = $\frac{\text{USGPM x Head Feet x S.G.}}{3960}$ or $\frac{\text{BPD x Head Feet x S.G..}}{136000}$

Pump Input H.P. (Brake H.P.) = $\frac{\text{Pump Output H.P.}}{\text{Pump EFF}}$

Motor Output H.P. (Brake H.P.) = Pump Input H.P. (H.P. Required by Pump)

Three Phase Motor

Motor Output H.P. (Brake H.P.) = $\frac{\text{1.732 x Volts x Amps x P.F.. x Motor EFF}}{746}$

Motor Input H.P. = $\frac{\text{Motor Output H.P.}}{\text{Motor EFF}}$

Motor Input KW = Motor Input H.P.. x 0.746 or $\frac{\text{1.732 x Volts x Amps x P.F.}}{1000}$

Motor Input KVA = $\frac{\text{Motor Input H.P..}}{\text{P.F..}}$ or $\frac{\text{1.732 x Volts x Amps}}{1000}$

Surface Power (KVA) = $\frac{\text{1.732 X (Motor Volts + Volts Drop In Cable) x Amps}}{1000}$

Efficiency Calculations

Motor EFF = $\frac{\text{Motor Output H.P..}}{\text{1.341 x Motor Input KW}}$

Pump EFF = $\frac{\text{USFPM x Head Feet x S.G.. x 746}}{\text{3960 x Motor Volts x Amps P.F.. x Motor EFF x 1.732}}$

When:

USGPM = Flowrate Expressed in United States Gallons Per Minute
S.G.. = Specific Gravity of the Fluid (Water=1.0 kg/litre)
BPD = Flowrate Expressed in in Barrels Per Day
H.P. = Horsepower
P.F. = Power Factor (Always Less Than 1 for Inductive Loads)
EFF = Efficiency Expressed as Decimal (i.e. 95% = 0.95)
KW = Kilowatts
KVA = Kilovolt - Ampere

Pump Affinity Laws Due to Speed Changes

Flowrate is directly proportional to speed

$$Q2/Q1 = N2/N1$$

Where: Q= Flow Rate
N=Speed from RPM or Hertz
H=Head
P=Horsepower

Head is proportional to the square of the speed ratio

$$H2/H1 = (N2/N1)2$$

Power is proportional to the cube of the speed ration

$$P2/P1 = (N2/N1)3$$

Pump Shaft Loading Due to Speed Changes

Shaft power loading is directly proportional to speed

$$SHP2/SHP1 = N2/N1$$

SHP= Shaft Horsepower Rating

Head Conversion Calculations

1 PSI = 2.31 feet HEAD / S.G.

1 foot HEAD = 0.433 psi x S.G.

Common Conversion Factors

GIVEN	MULTIPLY BY	TO OBTAIN	GIVEN	MULTIPLY BY	TO OBTAIN
ACRE FEET	7758	BARRELS	GRAMS/CM3	0.036	POUNDS/INCH^3
ACRES	0.4047	HECTARES	GRAMS/CM2	98.07	PSI
ACRES	43560	FEET^2	HORSE POWER	0.746	KILOWATTS
ATMOSPHERES	1.00323	KG/CM^2	INCHES	2.54	CENTIMETERS
ATMOSPHERES	14.696	PSI	INCHES	0.025	METERS
BARRELS	5.614	FEET^3	KILOGRAMS	35.27	OUNCES
BARRELS	0.15898	METERS^3	KILOGRAMS	2.205	POUNDS
BARRELS	42	GALLONS	KG/M3	0.062	POUNDS/FT^3
BPD	0.159	M^{3}PD	KG/CM2	14.22	PSI
BPD/PSI	0.0231	M^{3}PD/KPa			
BARRELS	0.15625	METRIC TONS	KILOMETERS	0.621	MILES
BARS	14.503	PSI	KILOWATTS	1.341	HORSEPOWER
CELSIUS	(^{0}Cx9/5)+32	FAHRENHEIT	LBS/FT	1.49	KG/METER
CENTIMETERS	0.03281	FEET	LITERS	0.264	GALLONS
CENTIMETERS	0.3937	INCHES	LITERS	0.035	FEET^3
CENTIMETERS	0.01094	YARDS	LITERS	61.03	INCHES^3
CM^3	0.06102	INCHES^3	LITERS/HOUR	0.004	GPM
CM^3	0.03381	FLUD OUNCES	LITERS/SEC.	15.85	GPM
FEET^3	0.02832	METERS^3	LITERS/SEC.	2.119	FT^3/MIN
FEET^3	7.48	GALLONS	METERS	3.281	FEET
FEET^3	28.316	LITERS	METERS	39.37	INCHES
FEET^3/MIN	0.4719	LITERS/SEC	METERS	1.094	YARDS
FEET^3/MIN	0.02832	M^3/MIN	MILES	1.609	KILOMETERS
FEET^3/WATER	62.366	POUNDS	MILLIMETERS	0.039	INCHES
INCHES^3	16.387	CM^3	POUNDS	0.454	KILOGRAMS
INCHES^3	0.01639	LITERS	PSI	6.895	KILOPASCALS
METERS^3	6.289	BARRELS	SCF/BARREL	0.177	M^3/M^3
METERS^3	35.315	FEET^3	CENTIMETERS^2	0.155	INCHES^2
METERS^3	1.308	YARDS^3	FEET^2	0.093	METERS^2
METERS^3	264.2	GALLONS	INCHES^2	6.452	CM^2
METERS^3/HR	4.4028	GPM	INCHES^2	645.2	MM^2
FAHRENHEIT	(^{0}F-32)5/9	CENTRIGRADE	KILOMETERS^2	0.386	MILES^2
FEET	30.48	CENTIMETERS	METERS^2	10.76	FEET^2
FEET	0.3048	METERS	METERS^2	1.196	YARDS^2
FEET OF WATER	0.0295	ATMOSPHERES	MILES^2	640	ACRES
GALLONS	0.02381	BARRELS	MM^2	0.002	INCHES^2
GALLONS	0.00379	METERS^3	YARDS^2	0.836	METERS^2
GALLONS	231	INCHES^3	TONS	2000	POUNDS
GALLONS	3.785	LITERS	TONS	907.2	KILOGRAMS
GPM	34.296	BPD	TONS	0.907	TONS METRIC
GPM	227.1	LITERS/HOUR	TONS-METRIC	2205	POUNDS
GPM	0.0609	LITERS/SEC	TONS-METRIC	1.102	TONS METRIC
IMP. GALLONS	1.201	GALLONS US	WATTS	0.001	HORSEPOWER
GAL. WATER	8.337	POUNDS	YARDS	0.914	METERS^2
GRAMS	0.0353	OUNCES	YARDS	91.44	CENTIMETERS

API Tubulars Data

API REGULAR CASING SIZE AND OD	THREAD	WEIGHT LBS/FT	DIAMETER(INCHES) OD	ID	DRIFT	COUPLING OD"
4 1/2"	8 rd	9.5	4.500	4.090	3.965	5.000
		10.5	4.500	4.052	3.927	5.000
		11.6	4.500	4.000	3.875	5.000
5 1/2"	8 rd	15.5	5.500	4.950	7.825	6.050
		17.0	5.500	4.892	4.767	6.050
		20.0	5.500	4.778	4.653	6.050
6 5/8"	8 rd	17.0	6.625	5.136	6.010	7.390
		24.0	6.625	5.921	5.796	7.390
7"	8 rd	20.0	7.000	6.456	6.331	7.656
		23.0	7.000	6.366	6.241	7.656
		26.0	7.000	6.276	6.151	7.656
8 5/8"	8 rd	28.0	8.625	8.017	7.892	9.625
		36.0	8.625	7.825	7.700	9.625
9 5/8"	8 rd	36.0	9.625	8.921	8.765	10.625
		40.0	9.625	8.835	8.679	10.625
10 3/4"	8 rd	40.5	10.750	10.050	9.894	11.750
		55.5	10.750	9.760	9.604	11.750
13 3/8"	8 rd	48.0	13.375	12.715	12.559	14.375
		68.0	13.375	12.415	12.259	14.375

API LINE PIPE NORMAL SIZE OD						
1 1/4"		11 1/2V	2.3	1.660	1.380	2.054
1 1/2"		11 1/2V	2.8	1.900	1.610	2.200
2"	2 3/8"	11 1/2V	3.8	2.375	2.067	2.875
2 1/2"	3 1/2"	8V	7.7	3.500	3.068	4.000
3"	3 1/2"	8V	11.7	4.500	4.026	5.200
3 1/2"	6 5/8"	8V	19.5	6.625	6.065	7.390
4"	8 5/8"	8V	25.6	8.625	8.071	9.625

API TUBING (EUE)						
1 1/2"		10rd	2.9	1.900	1.610	1.516	2.500
2"	2 3/8"	8rd	4.7	2.375	1.995	1.901	3.063
2 1/2"	2 7/8"	8rd	6.5	2.875	2.441	2.347	3.668
3"	3 1/2"	8rd	9.3	3.500	2.992	2.867	4.500
3 1/2"	4"	8rd	11.0	4.000	3.476	3.351	5.000
4"	4 1/2"	8rd	12.8	4.500	3.958	3.833	5.563

API TUBING (NON UPSET)						
1 1/2"		10rd	2.8	1.900	1.610	1.516	2.200
2"	2 3/8"	10rd	4.0	2.375	2.041	1.947	2.875
2 1/2"	2 7/8"	10rd	6.4	2.875	2.441	2.347	3.500
3"	3 1/2"	10rd	7.7	3.500	3.068	2.943	4.250
3 1/2"	4"	8rd	9.5	4.000	3.548	3.423	4.750

Electrical Terms for the Submersible Pump Industry

Alternating Current (AC) - an electrical current that reverses its direction at recurring intervals

Amp – abbreviation for *ampere* which is the measure of electrical flow

Armored Cable (BX) - metal sheathed flexible cable or down hole 3 phase submersible cable

Arrestor (surge) - stops or prevents a surge of electricity (such as from lightening) from harming downhole equipment

Circuit – the pathway an electrical current travels to and from the main source

Circuit Breaker – a device/switch which regulates the circuit's amp capacity – if the predetermined amperage is exceeded, this *opens* the circuit (remember, the circuit is a closed 'loop')

CODE – Implemented to ensure electrical safety measures. Canadian Electric Code (CEC), National Electric Code (NEC)

Conductor – material through which electricity flows; for the most part wire; cable (3 conductor)

Conduit – tube, pipe, or passageway that is used to house electrical wires

Continuity – uninterrupted electrical path, the complete flow along a circuit (power source to fixture and back)

CSA – Canadian Standards Association

Current – electrical flow through conductors measured in Amp's

Current Transformer (CT) - transformer used in instrumentation to assist in the measurement of current. The current ratio of a CT is utilized to reduce the high motor current to an 0-5 Amp typical motor controller current measuring input

Cycle – sequence of complete alternation (negative and positive) of a current

Direct Current (DC) - electrical current that flows in only one way

Dielectric Tests – tests conducted at a much higher rate than rated nameplate voltage to assure insulation quality

Disconnect – a device through which the conductors of a circuit are disconnected from their source

Frequency – the number of complete cycles per unit of time for a periodic quantity such as alternating current

Fuse – tube filled with combustible matter, metal band melts when circuit current exceeds its capacity

Gauge – refers to the thickness of wire or the *AWG (American Wire Gauge)*; also applies to bands and sheet metal.

Ground – an electrical conductor connected to the ground/earth

Harmonic – a sinusoidal component of an AC voltage that is a multiple of fundamental wave form frequency

Hertz (Hz) - unit of frequency, one Hz equals one cycle per second

Hot – 'live' wire that always carry a current (unless interrupted) as opposed to the neutral or ground

Hi Pot – an electrical test where voltage is applied at a higher rate to assure insulated valve and that an electrical breakdown does not occur

Junction Box (J-Box) - a box in which wires are joined together from the wellhead to the main power source (vents gas that might migrate from the down hole cable)

Knockout – something found on an outlet box, switch-box, or J-box, which needs to be 'knocked out' to accommodate wires

MegOHM – 1,000,000 OHMS

Megger – an electrical test where voltage is applied to test insulative values of the equipment

Neutral – paired with hot wires returns the current back to origin to complete circuit

OHM – unit of resistance

Open Circuit – circuit with a physical interruption like a switch, disconnection, burnt fuse, etc.

Raceway – electrical wires and/or cables in a specified space

Receptacle – electrical plug

Short Circuit – bad connection between wires

Splice – making a connection or repair assuring electrical and mechanical properties to down hole submersible cable

Stranded Wire – conductor wire made of several thinner strands of wire, twisted and braided together

Switch – device used to continue, disrupt, or redirect a circuit

Switchboard – a contained group of switches, relays, circuit breakers, etc. used to control distribution of power to other distribution equipment and larger loads

Switch Gear – see switchboard

Terminal – *screw type:* the wire is screwed to the device
push-in type: a stripped wire can be pushed into the acceptor

Transformer – a device that converts voltages

Volt – electrical pressure unit

Voltage – sufficient pressure to cause electrical current to flow

Watt – a measure of electrical power

VSD – Variable Speed Drive. A controller which allows you to vary the speed of the motor through modulations and applied frequency.

Engineering Tables

Desired Data	Alternating Current Single Phase	Alternating Current Three Phase
Kilowatts	$\frac{\text{Volts x Amp x P.F.}}{1000}$	$\frac{\text{1.73 x Volts x Amp x P.F.}}{1000}$
Kilovolt—Ampere	$\frac{\text{Volts x Amp}}{1000}$	$\frac{\text{1.73 x Volts x Amp}}{1000}$
Horsepower (Output)	$\frac{\text{Volts x Amp x 746 x 100}}{\text{EFF x P.F.}}$	$\frac{\text{1.73 x Volt x Amp x EFF x P.F.}}{\text{746 x 100}}$
Ampere (When H.P. is known)	$\frac{\text{H.P. x 746 x 100}}{\text{Volts x EFF x H.P.}}$	$\frac{\text{H.P x 746 x 100}}{\text{1.73 x Volts x EFF x H.P.}}$
Ampere (When Kilowatts are known)	$\frac{\text{Kilowatts x 1000}}{\text{Volts x P.F.}}$	$\frac{\text{Kilowatts x 1000}}{\text{1.73 x Volts x P.F.}}$
Cable Volt Loss		As Per Chart
Cable Volt Drop		As Per Chart
Surface Voltage	Motor Name Plates + Volt Drop + Cable Drop	
Surface KVA		$\frac{\text{Surf Volt x Mtr Amp x 1.73}}{1000}$
60 Hz Motor Voltage Conversion to 50 Hz		$\frac{\text{Mtr NP Volts x 0.883}}{\text{NP Amps Remain the Same}}$

Surface Cable Requirements

Allowable Ampacities for
not more than 3 Copper Conductors in Raceway or Cable
Based on Ambient Temperature of 30°C*

	Allowable Ampacity†‡‡					
	60°C‡	75°C‡	85 – 90°C‡	110°C‡	125°C‡	200°C‡
Size AWG kcmil	Type TW	Types RW75, TW75	Types R90, RW90 T90 NYLON Paper Mineral-Insulated Cable**	See Note	See Note	See Note
14	15	15		30	30	30
12	20	20	15	35	40	40
10	30	30	20	45	50	55
8	40	45	30	60	65	70
6	55††	65	45	80	85	95
4	70	85	65	105	115	120
3	80	100	85	120	130	145
2	100	115	105	135	145	165
1	110	130	120	160	170	190
			140			
0	125	150		190	200	225
00	145	175	155	215	230	250
000	165	200	185	245	265	285
0000	195	230	210	275	310	340
			235			
250	215	255		315	335	-
300	240	285	265	345	380	-
350	260	310	295	390	420	-
400	280	335	325	420	450	-
500	320	380	345	470	500	-
			395			
600	355	420		525	545	-
700	385	460	455	560	600	-
750	400	475	490	580	620	-
800	410	490	500	600	640	-
900	435	520	515	-	-	-
			555			
1000	455	545		680	730	-
1250	495	590	585	-	-	-
1500	520	625	645	785	-	-
1750	545	650	700	-	-	-
2000	560	665	735	840	-	-
			775			
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7

For further information, refer to you CEC/NEC handbook
****See Table 5A for the correction factors to be applied to the values in Columns 2 to 7 for ambient temperatures over 30°C***
†The Ampacity of aluminum-sheathed cable is based on the type of insulation used on the copper conductors
Note: These ampacities are only applicable under special circumstances where the use of insulated conductors having this temperature rating are acceptable to the inspection department.

Transformer Troubleshooting

Condition	Possible Cause	Suggested Remedy
Hot Transformer	High ambient temperature	Improve ventilation or relocate to cooler location.
	Overload	Reduce load; reduce amperes by improving power factor with capacitors; check for circulating currents for paralleled transformers – different ratios or impedance's; check for open phase in delta bank.
	High voltage	Change circuit voltage, taps.
	Insufficient cooling	If other than naturally cooled, check fans, pumps, valves, and other units in cooling systems.
	Winding failure – incipient fault	See "No voltage – unsteady voltage."
	Short-circuited core	Test for exciting current and no-load loss; if high, inspect core, remove and repair; check core bolts, clamps and tighten; check insulation between laminations; if welded together, return to factory for repair or replacement.
Noisy Transformer	Overload	See "Hot Transformer" above.
	Metal part ungrounded, loose connection	Determine part and reason; check clamps, core and other parts normally grounded for loose or broken connections, bolt fallen out, nuts vibrated off, bolts, etc.; tighten loose clamps, bolts, nuts; replace missing parts.
	External parts and accessories in resonant vibration	Tighten items as above; in some cases, loosen to relieve pressure causing resonance and install shims.
	Incipient fault – core or winding	See "Hot Transformer" above.

Transformer Troubleshooting

Condition	Possible Cause	Suggested Remedy
Bushing Flashover	Lightning	Check lightning protection; arresters, connections, lugs, grounds.
	Dirty bushings	Clean porcelains; check source of dirt.
Broken Bushing or Parts	Strains on terminal connections	Flexible connections inserted between terminals and cables or busses to remove strain from bushing.
No Voltage – Unsteady Voltage	Winding failure – lightning; overload; short circuit from foreign object or low strength dielectric	Check winding, remove foreign object or damaged material: repair or replace parts of insulation materials.
Rust and Paint Deterioration	Weather, polluted, corrosive or salt atmosphere ; overloads Excessive heating discoloration	Remove rust and deteriorated paint; clean surfaces. Repaint with proper paints and sufficient coatings.
Hot Neutral Line	Overload	Too small neutral conductor: replace; severe unbalance between phases: rebalance and equalize loads.
	One leg of wye bank open	Check associated fuse; if blown, remove cause and replace; check for open circuit in winding or transformer in bank.
		Measure odd harmonic activity amps with RMS meter.

Maximum Fuse Ratings as a Percentage with a Step Down Transformer Application

Type of Motor	Per Cent of Full-Load Current		
	Maximum Fuse Rating		Maximum Setting Time-Limit Type Circuit Breaker
	Time Delay* "D" Fuses	Non - time Delay	
Alternating Current			
Single-Phase all types	175	300	250
Squirrel-Cage and Synchronous:			
Full Voltage, Resistor and Reactor Starting	175	300	250
Auto-Transformer Starting:			
Not more than 30 A	175	250	200
More than 30 A	175	200	200
Wound Rotor	150	150	150
Direct Current	150	150	150

Maximum Fuse Ratings as a Percentage with a Step Up Transformer Application

- Overcurrent protection for power and distribution transformers rated 750 V or less, other than dry type transformers shall be protected by an individual overcurrent device on the primary side, rated or set at not more than 150% of the rated primary current (surface amperage requirement).

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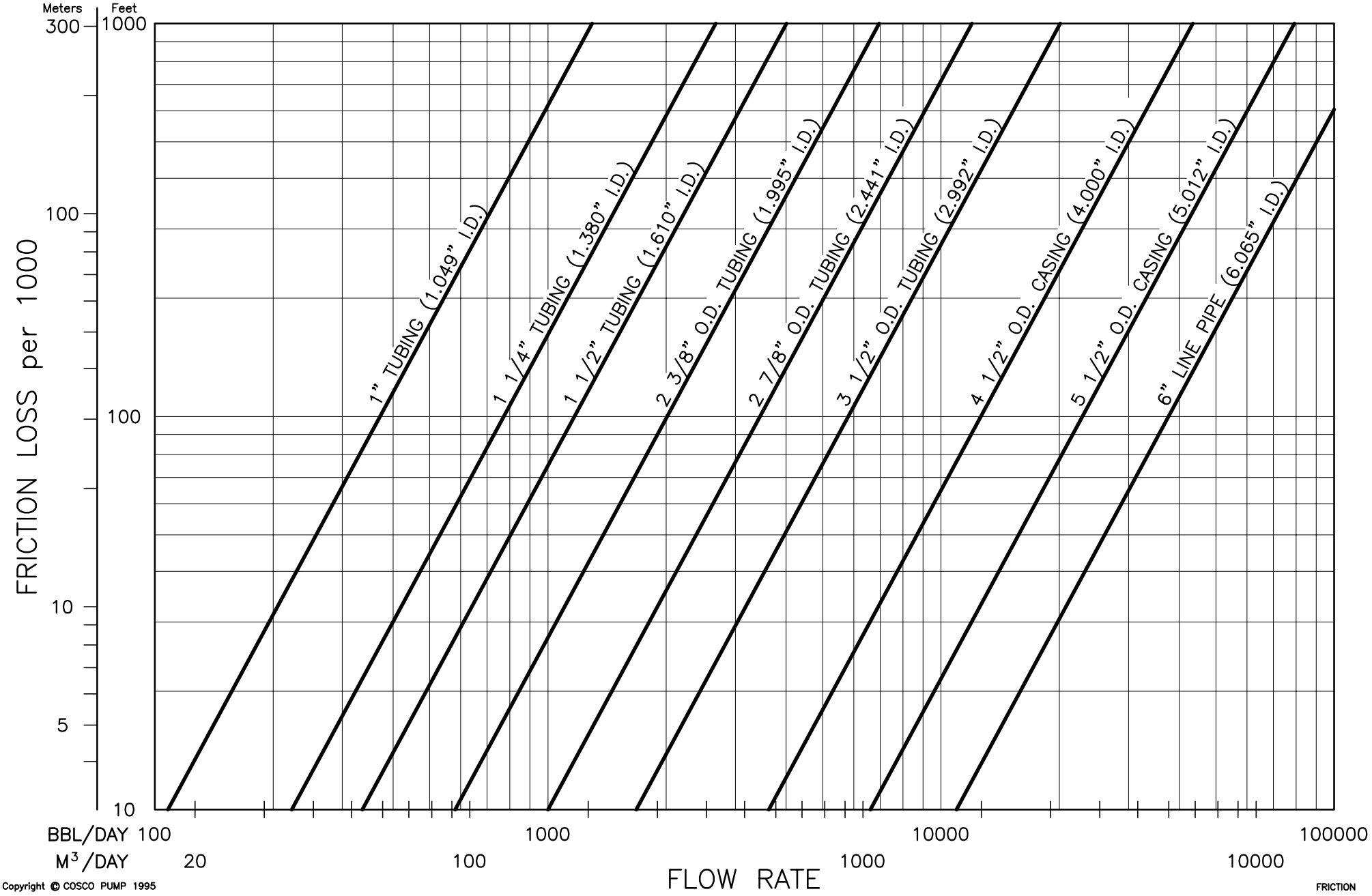
FRICTION LOSS IN A.P.I. TUBULARS



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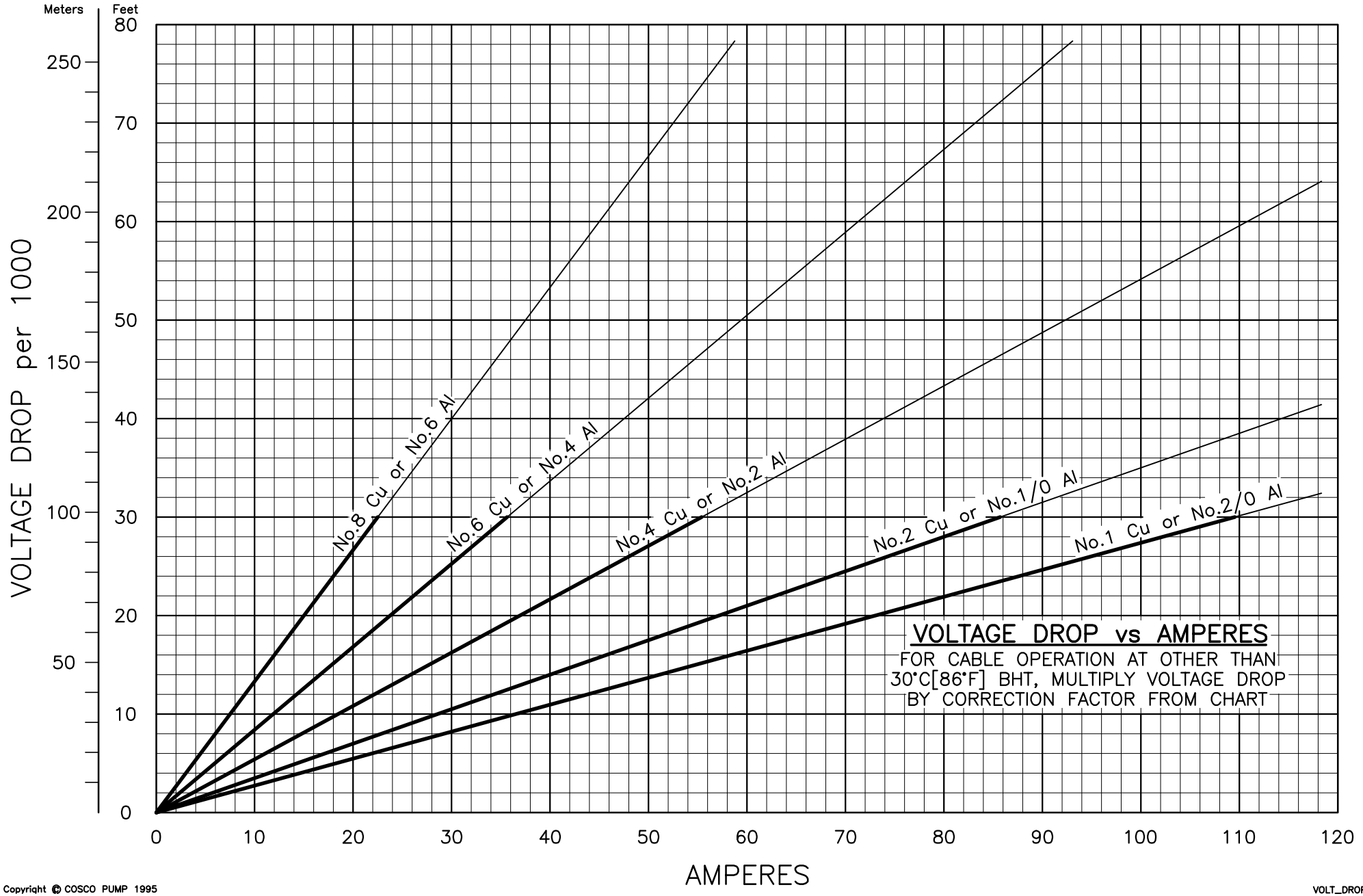
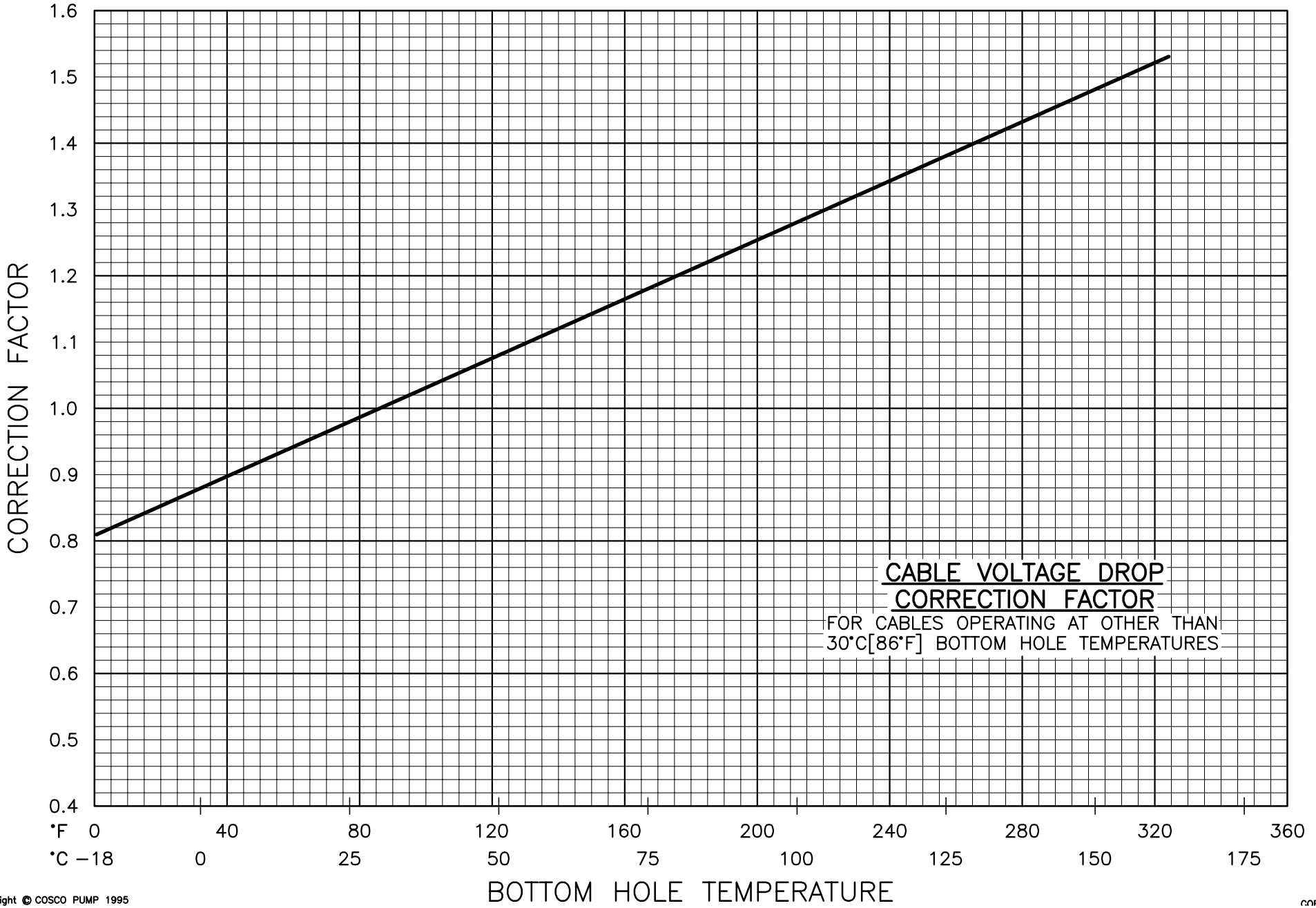
VOLTAGE DROP vs AMPERES



VOLT_DROP

COSCO PUMP COMPANY LTD.

CABLE VOLTAGE DROP CORRECTION FACTOR



CORRECTION

Cable Conductor Sizes

AWG	mm^2	AWG	mm^2	AWG	mm^2	AWG	mm^2
30	0.05	18	0.75	6	16	300 MCM	150
28	0.08	17	1.00	4	25	350 MCM	185
26	0.14	16	1.50	2	35	500 MCM	240
24	0.25	14	2.50	1	50	600 MCM	300
22	0.34	12	4	2/0	70	750 MCM	400
21	0.38	10	6	3/0	95	1000 MCM	500
20	0.50	8	10	4/0	120		

This cross reference list shows equivalent nominal values. Actual cross sections may vary. The AWG values are approximate. If the cables are made to European Standards (mm^2) and vice versa. In critical applications, where the current reaches upper limits, the deviating operation conditions for installation and laying according to standards are to be taken into consideration.