UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Utilities Service

BULLETIN 1751F-630

SUBJECT: **Design of Aerial Plant**

TO: All Telecommunications Borrowers
RUS Telecommunications Staff

EFFECTIVE DATE: Date of Approval

EXPIRATION DATE: Seven years from effective date

OFFICE OF PRIMARY INTEREST: Outside Plant Branch, Telecommunications Standards Division

PREVIOUS INSTRUCTIONS: This bulletin replaces RUS Telecommunications Engineering & Construction Manual (TE&CM) Sections 630, Design of Aerial Plant, Issue 3, dated March 1962; Addenda 2 and 3, dated October 1966 and January 1979, respectively; and 611, Design of Pole Lines, Issue 3, dated March 1960; Addendum 3, dated October 1996.

FILING INSTRUCTIONS: Discard RUS TE&CM Sections 630, Design of Aerial Plant, Issue 3, dated March 1962; Addenda 2 and 3, dated October 1966 and January 1979, respectively; and 611, Design of Pole Lines, Issue 3, dated March 1960; Addendum 3, dated October 1996, and replace it with this bulletin. File with 7 CFR Part 1751 and is available to RUS staff on RUSNET.

PURPOSE: This bulletin provides RUS borrowers, consulting engineers, contractors and other interested parties with information on the design of aerial plant facilities.

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ABBREVIATIONS

AWG	American Wire Gauge
°C	Degrees Celsius
CFR	Code of Federal Regulations
cm	Centimeters
°F	Degrees Fahrenheit
ft	Feet
in.	Inches
kg/m	Kilograms per meter
lb/ft	Pounds per foot
LD	Loan Design
NAFTA	North American Free Trade Agreement
NEC	National Electrical Code
NESC	National Electrical Safety Code
m	Meter
mm	Millimeters
RUS	Rural Utilities Service
TE&CM	Telecommunications Engineering and Construction Manual

DEFINITIONS

Anchor: A device that serves as a reliable support to hold an object firmly in place. The term anchor is normally associated with cone, plate, screw, or concrete anchors, but the terms snub, deadman and anchor log are usually associated with pole stubs or logs set or buried in the ground to serve as temporary anchors. The latter are often used at pull and tension sites.

Anchor Guy: The buried element of a guy assembly that provides holding strength or resistance to guy wire pull.

Ground Clearance: The minimum separation between cables and the ground.

Guy: A tension member having one end secured to a fixed object and the other end attached to a pole or other structural part that it supports.

Heavy Loading District: Horizontal wind pressure, at a right angle to the line, of 4 pounds per square foot (190 Pascals) upon the projected area of the cylindrical surfaces of all supported wires (including suspension strand and cables) when coated with a radial thickness of 0.50 in. (12.5 mm) of ice at a temperature of 0°F (-20°C).

Lashed Aerial Cable: Cable that is attached to the separate suspension strand by lashing wire to support the cable.

Light Loading District: Horizontal wind pressure, at a right angle to the line, of 9 pounds per square foot (430 Pascals) upon the projected area of the cylindrical surfaces of all supported wires (including suspension strand and cables) at a temperature of 30°F (-1°C).

Loan Design: A comprehensive engineering plan for the project used to support a loan application to RUS.

Medium Loading District: Horizontal wind pressure, at a right angle to the line, of 4 pounds per square foot (190 Pascals) upon the projected area of the cylindrical surfaces of all supported wires (including suspension strand and cables) when coated with a radial thickness of 0.25 in. (6.5 mm) of ice at a temperature of 15°F (-10°C).

Pole: A column of wood supporting overhead cables usually by means of brackets.

Pole Line: A series of poles arranged to support cables above the surface of the ground: and the structures and cables supported thereon.

Push Brace: A supporting member, usually of timber, placed between a pole or other structural part of a line and the ground or a fixed object.

RUS Accepted (Material and Equipment): Material and equipment which RUS has reviewed and determined that:

a. Final assembly is conducted within the United States, Mexico, or Canada, or any of their respective territories and the cost of United States, Mexican, or Canadian, manufactured components, in any combination, is more than 50 percent of the total cost of all components utilized in the material or equipment, and

b. The material or equipment complies with pertinent RUS or industry standards and field experience has demonstrated that the material or equipment is suitable for use on systems of RUS telecommunications borrowers.

RUS Technically Accepted (Material and Equipment): Material and equipment which RUS has reviewed and determined that:

a. Final assembly is not conducted within the United States, Mexico, or Canada, or any of their territories, or the cost of components within the material or equipment which are manufactured within the United States, Mexico, or Canada, or any of their territories, cost 50 percent or less than the total cost of all components utilized in the material or equipment, and

b. The material or equipment complies with pertinent RUS or industry standards and field experience has demonstrated that the material or equipment is suitable for use on systems of RUS telecommunications borrowers.

Sag: The distance measured vertically from a cable to the straight line joining its two points of support. Unless otherwise stated in the NESC, the sag referred to is the sag at the midpoint of the span.

Self-Supporting Aerial Fiber Optic Cable: A cable consisting of one or more buffered optical fibers factory assembled with a messenger that supports the cable.

Span Length: The horizontal distance between two adjacent supporting points of a cable.

Suspension Strand: A stranded group of wires supported above the ground at intervals by poles or other structures and employed to furnish within these intervals frequent points of support for cables.

1. GENERAL

1.1 This bulletin discusses in particular the design of aerial plant using filled copper cables and filled fiber optic cables. The information and recommendations in this bulletin are advisory.

1.2 Aerial plant refers to telecommunication copper cables and fiber optic cables that are attached to utility poles at varying span lengths by lashing cables to separate suspension strands. Filled fiber optic cables may also be attached to utility poles using cables containing an integrated suspension strand. Filled fiber optic aerial cables containing integrated suspension strands are referred to as a self-supporting fiber optic cables.

1.3 Additional information for the use in the design of aerial plant facilities can be found in following RUS documents:

a. TE&CM Section 116, Plant Engineering and Record System;

b. TE&CM Section 204, Telephone System Design;

c. TE&CM Section 210, Telephone System Design - Sizing Criteria;

d. TE&CM Section 218, Plant Annual Cost Data for System Design Purposes;

e. TE&CM Section 219, Present Worth of Annual Charge Studies for System Design;

f. TE&CM Section 424, Design Guideline for Telecommunications Subscriber Loop Plant;

g. TE&CM Section 628, Plastic Insulated Cable Plant Layout;

h. TE&CM Section 635, Construction of Aerial Plant;

i. TE&CM Section 650, Guy and Anchors on Wire and Cable Lines;

j. RUS Bulletin 345-153, Specifications and Drawings for Construction of Pole Lines, Aerial Cables and Wires (RUS Form 515f);

k. RUS Bulletin 344-3, "Buy American" Requirement, as amended by the NAFTA;

l. RUS Bulletin 1728F-700, RUS Specification for Wood Poles, Stubs and Anchor Logs;

m. RUS Bulletin 1751F-626, Staking of Aerial Plant;

n. RUS Bulletin 1751F-670, Outside Plant Corrosion Considerations;

o. RUS Bulletin 1751F-801, Electrical Protection Fundamentals;

p. RUS Bulletin 1751F-815, Electrical Protection of Outside Plant;

q. RUS Bulletin 1751H-601, Lightwave Fundamentals, Systems, and Application;

r. RUS Bulletin 1753F-401(PC-2), RUS Standard for Splicing Copper and Fiber Optic Cables (codified under 7 CFR Part 1755.200);

s. 7 CFR Part 1751, Subpart B, State Telecommunications Modernization Plan; and

t. 7 CFR Part 1753.6, Standards, Specifications, and General Requirements.

2. DESIGN CONSIDERATIONS

2.1 Aerial plant construction should be the method of construction when the initial construction cost is lower than the initial construction cost of buried plant construction and when the annual cost of the aerial plant facilities are lower than the annual cost of buried plant facilities. Aerial plant construction should also be the method of construction when rock conditions are encountered that economically restrict the use of direct buried plant.

2.2 Aerial plant construction involving the use of joint occupancy utility poles should only be considered when required by local, State, or Federal ordinances or regulations. When joint occupancy of aerial electric and telecommunications cables is considered, the design and construction of the joint occupancy facilities should performed in accordance with the latest editions of the NEC, NESC, local or State regulations, or Federal regulations. When the local, State, or Federal regulations are more stringent than the NEC or NESC codes, the more stringent requirements should be observed.

2.3 For outside plant aerial facilities using copper cables, circuit requirements should be thoroughly evaluated to provide sufficient margin in the sizing of both aerial distribution and feeder cables. The sizing of the copper cables should be based on the recommendations listed in RUS TE&CM Section 210, Telephone System Design - Sizing Criteria. The assigning of cable pairs should be based on the recommendations listed in RUS TE&CM Section 628, Plastic Insulated Cable Plant Layout.

2.4 For outside plant aerial facilities using fiber optic cables, circuit requirements should be thoroughly evaluated to provide sufficient margin in the sizing of the cables. The sizing of the fiber optic cables should be based on the fiber pair requirements of the approved LD plus the number of fiber pairs needed for future growth.

2.5 Serving additional subscribers not anticipated at the time of construction may become a problem in aerial plant design. Therefore thorough planning is of utmost importance. Long range subscriber estimates by grade of service should be made prior to the preparation of the LD. The estimate should take into account the upgrading of existing services and the addition of new subscribers.

2.6 For copper aerial plant, the design should provide for the optimum use of fine gauge cable (22 and 24 gauge conductors). Care should be exercised in the design to ensure that transmission requirements are met and that high lightning areas are considered.

2.7 For copper aerial plant, the choice of the proper gauge conductors should depend on the transmission and signaling requirements. Care should be exercised in selecting the cables since initial cost differentials between the various cable types, sizes, and conductor gauges can be appreciable. Where economic costs consistent with the State Telecommunications Modernization Plan (7 CFR Part 1751, Subpart B) indicate the use of digital carrier and other types of electronic equipment over physical circuits, the electronic equipment should be installed.

2.8. For optical fiber aerial plant, the design should provide for the use of either dispersion-unshifted single mode fibers (operates at both the 1310 and 1550 nanometer windows) or dispersion-shifted single mode fibers (operates at the 1550 nanometer window). The choice as to which single mode fiber to use should depend on the optical system's length and the transmission and signaling requirements.

2.9 For lightwave systems, the design should be prepared in accordance with the recommendations listed in RUS Bulletin 1751H-601, Lightwave Fundamentals, Systems, and Application.

3. ECONOMIC CONSIDERATIONS

3.1 The decision to construct the project area using aerial plant facilities should be based on an economic analysis using the recommendations referenced in RUS TE&CM Sections 218, Plant Annual Cost Data for System Design Purposes and 219, Present Worth of Annual Charge Studies for System Design.

3.2 If the economic analysis indicates that the project area should be constructed using aerial plant facilities, a decision should then be made regarding the design of the project area using either an all copper design or a combination copper/fiber design.

3.3 Selection of either the all copper design or the combination copper/fiber design should be based on a long-term economic plan, good engineering judgement, and the individual State Telecommunications Modernization Plan (7 CFR Part 1751, Subpart B). The initial and annual cost data should be used as economic guidelines to supplement and support the engineering judgement and decision. The objective is to choose the most suitable elements of the new plant facilities. In general, the design with the lowest annual cost should be selected. However, other considerations such as reliability and quality of service, connecting company arrangements, flexibility for meeting potential new market opportunities, or other effects on system operation may outweigh annual cost considerations.

3.4 Local characteristics of the project area should be known before comparative cost studies are commenced. It should also be determined if special types of equipment or cable are required so that the added expense can be evaluated.

4. CONSTRUCTION MATERIALS

4.1 For all aerial plant construction projects financed with RUS loan funds, RUS regulation 7 CFR Part 1753.6 requires that only RUS accepted materials be used.

4.2 RUS technically accepted, nondomestic manufactured materials, may also be used on aerial plant construction projects. Before technically accepted materials can be used on aerial plant construction projects, permission is required from the RUS borrower. In addition, borrower's are required to ensure that the cost of the technically accepted materials comply with RUS Bulletin 344-3, "Buy American" Requirement, as amended by NAFTA.

4.3 RUS Bulletin 1728F-700, RUS Specification for Wood Poles, Stubs and Anchor Logs, lists the requirements for wood poles that should be used by RUS borrowers in aerial plant construction.

5. POLE LINE DESIGN

5.1 Pole lines for aerial plant construction should be designed based on the pole's class and length. The class of pole selected should be determined by the pole's strength and transverse load requirements. The length of the pole should be determined by ground clearances, sags. etc.

5.2 Pole lines for the majority of aerial plant construction performed by RUS borrowers should be designed for Grade C construction which is defined in Section 24, Grades of Construction, of the latest edition of the NESC.

5.3 Pole lines for aerial plant construction involving the crossing of railroads, limited-access highways, and other special situations should be designed for Grade B construction which is defined in Section 24 of the latest edition of the NESC.

5.4 To assist RUS borrowers in the design of the pole line for aerial plant construction, Figure 1 provides information on the number of poles per mile versus the span length.

6. POLE CLASS SELECTION

6.1 Grade C construction of the NESC specifies specific overload capacity factors of poles use in aerial plant construction. To ensure that poles have adequate strength to support aerial plant construction, poles should be designed to meet the overload capacity factors specified in NESC Rule 261 for Grade C construction.

6.2 Poles are divided into nine classes based on their rated breaking loads. The classes are numbered 1 through 10, with class 8 being omitted. The rated breaking loads are applied transversely 24 in. (60.9 cm) from the top of the pole. Table 1 lists the transverse breaking loads for each pole class:

TABLE 1
Transverse Breaking Loads

Pole Class	Pounds-Force	(Newtons)
1	4500	(20,017)
2	3700	(16,458)
3	3000	(13,345)
4	2400	(10,676)
5	1900	(8,452)
6	1500	(6,672)
7	1200	(5,338)
9	740	(3,292)
10	370	(1,646)

The values in the table for a given pole class are the same for all species of pole timber. For classes 1 to 7, the strength of any class is approximately 25 percent greater than the next weaker class.

6.3 The pole class selected is assumed to have the required strength to support the vertical loads. Vertical loads to which poles are subjected to are as follows:

a. Weight of the suspension strand;

b. Weight of the cable; and

c. The increase in weight when the suspension strand and cable are coated with ice.

6.4 Poles are also subjected to a transverse load. The transverse load is the load applied when the wind pressure occurs at a right angle to the direction of the pole line. Transverse loading on poles should be calculated using the storm loading assumptions for the three loading districts established in Section 25, Loading for Grades B, C, and D, of the latest edition of the NESC.

6.5 In addition to the transverse wind pressure load on the suspension strand and cable, the pole itself and attachments should also withstand the transverse wind pressure load. This additional load will vary due to differences in dimensions and length in any given pole class and type of attachments made on the pole. RUS has adopted as an approximation for this purpose 50 pounds-force (222 newtons) in the heavy and medium storm loading districts and 75 pounds-force (334 newtons) in the light storm loading district, applied 24 in. (60.9 cm) from the pole top.

6.6 The pole class for lashed filled copper and fiber optic cable should be selected based on the calculated transverse wind loading using the storm loading assumptions for the three loading districts established in Section 25 of the latest edition of the NESC and the average span length.

6.7 The pole class for self-supporting filled fiber optic cable should be selected based on the calculated transverse wind loading using the storm loading assumptions for the three loading districts established in Section 25 of the latest edition of the NESC and the average span length.

6.8 Poles used as push braces should be of the same class as the poles they brace.

6.9 Poles used as stubs for overhead and anchor guys should be of the same class as the poles to which they are associated.

7. SUSPENSION STRAND SELECTION

7.1 Suspension strands are available in utilities and extra high strength grades. Both the utilities and extra high strength grades come in 6M, 10M, and 16M sizes. The suspension strand size for cable in RUS borrowers' systems usually will be either 6M or 10M strand. The rated breaking strength (minimum breaking strength) of the 6M and 10M strands are 6,000 pounds-force (26,689 newtons) and 11,500 pounds-force (51,154 newtons), respectively. Aerial cable plant design is based on not exceeding 60 percent of the rated breaking strength of the suspension strand when the cable and strand are loaded as calculated according to assumptions of wind, ice, and temperature specified in accordance with the storm loading districts specified in Section 25 of the latest edition of the NESC. The 16M strand will permit longer spans than the 10M strand but it is a rather large size as compared to the cable diameters usually installed in RUS borrowers' telecommunications systems and is about 30 percent more costly than 10M strand. The 16M strand has a rated breaking strength of 18,000 pounds-force (80,067 newtons). The 16M strand is not recommended for use with cables weighing less than 1.5 lb/ft (2.2 kg/m).

7.2 Both the utilities and extra high strength grade suspension strands are available in three zinc coating weights referred to as Class A, Class B, and Class C coatings. The Class A coated strand has lowest zinc coating weight while Class C coated strand has the highest zinc coating weight. The Class A coated strand is the preferred suspension strand installed in RUS borrower telecommunications systems. The Class C coated suspension strand should be used in aerial plant construction where the Class A coated strand is subjected to excessive corrosion. RUS Bulletin 1751F-670, Outside Plant Corrosion Consideration, should be referenced to determine if the corrosion could be a problem in the construction area.

7.3 The integral support messenger of a self-supporting, filled, aerial fiber optic cable is a 0.25 in. (6.35 mm) diameter, 7 wire, extra high strength grade, Class A galvanized steel strand coated with a corrosion protective floodant.

8. SPAN LENGTHS

8.1 Span lengths for lashed, filled copper and fiber optic cables should be determined using the following factors:

a. Cable weight per ft (m);

b. Strand size;

c. Coating class;

d. Pole length;

e. Pole setting depth;

f. Maximum permissible sag;

g. Maximum span for 14 ft (9.1 m) clearance;

h. Poles per mile (kilometer);

i. Pole class;

j. Terrain;

k. Subscriber distribution;

l. Strand cost per mile (kilometer);

m. Pole cost per mile (kilometer) in place; and

n. Pole and strand cost per mile (kilometer).

8.2 Cable weights of filled copper cables by pair size, gauge, and insulation type which should be used for the cable weight factor in determining span lengths for copper cables in aerial plant construction projects are given in Tables 2 and 3.

TABLE 2
Cable Weights
Filled Copper Cables - Solid Insulation

	Cable Weights lb/ft (kg/m)			
Pair Size	19 AWG	22 AWG	24 AWG	26 AWG
6	0.2 (0.30)	0.1 (0.15)	0.1 (0.15)	-
12	0.3 (0.45)	0.2 (0.30)	0.1 (0.15)	-
18	0.4 (0.60)	0.2 (0.30)	0.1 (0.15)	-
25	0.5 (0.74)	0.3 (0.45)	0.2 (0.30)	0.1 (0.15)
50	0.9 (1.34)	0.5 (0.74)	0.3 (0.45)	0.2 (0.30)
75	1.3 (1.93)	0.7 (1.04)	0.5 (0.74)	0.3 (0.45)
100	1.8 (2.68)	0.9 (1.34)	0.6 (0.89)	0.4 (0.60)
150	2.6 (3.87)	1.3 (1.93)	0.8 (1.19)	0.6 (0.89)
200	3.3 (4.91)	1.7 (2.53)	1.1 (1.64)	0.7 (1.04)
300	4.9 (7.29)	2.4 (3.57)	1.6 (2.38)	1.0 (1.49)
400	6.4 (9.52)	3.2 (4.76)	2.1 (3.12)	1.3 (1.93)
600	-	4.7 (6.99)	3.1 (4.61)	2.0 (2.98)
900	-	6.9 (10.3)	4.5 (6.70)	2.9 (4.31)
1200	-	-	5.9 (8.78)	3.7 (5.50)
1500	-	-	7.3 (10.9)	4.7 (6.99)
1800	-	-	8.7 (12.9)	5.5 (8.18)
2100	-	-	10.0 (14.9)	6.4 (9.52)
2400	-	-	-	7.2 (10.7)

TABLE 3
Cable Weights
Filled Copper Cables - Expanded Insulation

Pair Size	Cable Weights lb/ft (kg/m) 19 AWG	22 AWG	24 AWG	26 AWG
6	0.1 (0.15)	0.1 (0.15)	0.1 (0.15)	-
12	0.2 (0.30)	0.1 (0.15)	0.1 (0.15)	-
18	0.3 (0.45)	0.2 (0.30)	0.1 (0.15)	-
25	0.4 (0.60)	0.2 (0.30)	0.2 (0.30)	0.1 (0.15)
50	0.7 (1.04)	0.4 (0.60)	0.3 (0.45)	0.2 (0.30)
75	1.0 (1.49)	0.6 (0.89)	0.4 (0.60)	0.3 (0.45)
100	1.4 (2.08)	0.7 (1.04)	0.5 (0.74)	0.3 (0.45)
150	2.0 (2.98)	1.0 (1.49)	0.7 (1.04)	0.5 (0.74)
200	2.6 (3.87)	1.4 (2.08)	1.0 (1.49)	0.6 (0.89)
300	3.8 (5.65)	2.0 (2.98)	1.3 (1.93)	0.9 (1.34)
400	5.1 (7.59)	2.6 (3.87)	1.7 (2.53)	1.1 (1.64)
600	7.5 (11.2)	3.8 (5.65)	2.5 (3.72)	1.7 (2.53)
900	-	5.7 (8.48)	3.7 (5.50)	2.4 (3.57)
1200	-	7.5 (11.2)	5.0 (7.44)	3.2 (4.76)
1500	-	9.2 (13.7)	6.1 (9.08)	4.0 (5.95)
1800	-	-	7.3 (10.9)	4.8 (7.14)
2100	-	-	8.4 (12.5)	5.5 (8.18)
2400	-	-	9.5 (14.1)	6.2 (9.23)
2700	-	-	-	6.7 (9.97)
3000	-	-	-	7.7 (11.5)
3300	-	-	-	8.4 (12.5)
3600	-	-	-	9.1 (13.5)

8.3 Cable weights of filled fiber optic cables by fiber size, strength member type, core type, and cable construction which should be used for the cable weight factor in determining span lengths for fiber optic cables in aerial plant construction projects are given in Tables 4 through 7.

TABLE 4
Cable Weights
Nonarmored Filled Fiber Optic Cables
Multiple Loose Tube Core

Fiber Sizes	Cable Weights lb/ft (kg/m) Nonmetallic Strength Member	Metallic Strength Member
2 - 36	0.07 (0.10)	0.08 (0.12)
38 - 72	0.09 (0.13)	0.10 (0.15)
74 - 84	0.10 (0.15)	0.11 (0.16)
86 - 96	0.11 (0.16)	0.12 (0.18)
98 - 108	0.13 (0.19)	0.14 (0.21)
110 - 120	0.15 (0.22)	0.16 (0.24)
122 - 132	0.16 (0.24)	0.17 (0.25)
134 - 216	0.18 (0.27)	0.19 (0.28)
218 - 264	0.20 (0.30)	0.21 (0.31)

TABLE 5
Cable Weights
Armored Filled Fiber Optic Cables
Multiple Loose Tube Core

Fiber Sizes	Cable Weights lb/ft (kg/m) Nonmetallic Strength Member	Metallic Strength Member
2 - 36	0.11 (0.16)	0.13 (0.19)
38 - 72	0.14 (0.21)	0.15 (0.22)
74 - 84	0.16 (0.24)	0.17 (0.25)
86 - 96	0.18 (0.27)	0.19 (0.28)
98 - 108	0.20 (0.30)	0.21 (0.31)
110 - 120	0.22 (0.33)	0.23 (0.34)
122 - 132	0.24 (0.36)	0.25 (0.37)
134 - 216	0.27 (0.40)	0.28 (0.42)
218 - 264	0.28 (0.42)	0.29 (0.43)

TABLE 6
Cable Weights
Nonarmored Filled Fiber Optic Cables
Central Core Tube

Fiber Sizes	Cable Weights lb/ft (kg/m) Nonmetallic Strength Member	Metallic Strength Member
6 - 60	0.08 (0.12)	0.10 (0.15)
62 - 96	0.11 (0.16)	0.15 (0.22)

TABLE 7
Cable Weights
Armored Filled Fiber Optic Cables
Central Core Tube

Fiber Sizes	Cable Weights lb/ft (kg/m) Nonmetallic Strength Member	Metallic Strength Member
6 - 60	0.11 (0.16)	0.13 (0.19)
62 - 96	0.14 (0.21)	0.18 (0.27)

8.4 For lashed, filled copper cables, Figures 2 through 10 indicate the span length limits for poles of various lengths on level ground which will provide 14 ft (4.3 m) of final unloaded ground clearance at 60°F (15.6°C) for cables of various weights on the 6M, 10M, and 16M strands in the three storm loading districts referenced in Section 25 of the latest edition of NESC. Cost studies indicate that 30 ft (9.1 m) Class 7 poles are strong enough to provide the spans at the lowest cost. The 30 ft (9.1 m) poles have an advantage over 25 ft (7.6 m) poles in providing greater height for aerial service wire road crossings.

8.5 For lashed, filled fiber optic cables, recommended span length limits for poles of various lengths on level ground which will provide 14 ft (4.3 m) of final unloaded ground clearance at 60°F (15.6°C) for cables of various weights on the 6M strands in the three storm loading districts referenced in Section 25 of the latest edition of NESC should be obtained from fiber optic cable manufacturers.

8.6 For lashed, filled copper and fiber optic cables, an occasional span that is shorter than adjacent spans should not be a concern except from the standpoint of the effect of short spans on the average spans and, therefore, the number of poles needed. However, when an individual span occurs which is appreciably longer than the average span in its section of line, consideration should be given to the question of proper limits for such spans before employing special construction methods. Special long span construction is recommended for such occasional spans when the length of the span in question is more than 50 percent than the average of five adjacent spans in either direction.

8.7 Long span construction for lashed, filled copper and fiber optic cables may be necessary in the aerial plant because of terrain (such as river crossings, etc.) that make construction of normal span lengths impracticable. When long span construction is contemplated, the long span construction should be designed for the particular situation.

8.8 One method of long span construction could be the use of catenary suspension strands to avoid excessive sags on spans. When catenary suspension strand construction is contemplated, the following factors should be consider:

a. Selection of a cable suspension strand which would be strong enough to support the cable without the catenary strand;

b. Selection of a catenary strand as strong or stronger than the cable suspension strand;

c. Selection of suitable heights and classes of poles;

d. Pole setting depths and their footings; and

e. Side and head guy requirements.

8.9 When catenary suspension strand construction is employed, the cable suspension strand should be fastened to long span poles at heights which will conform to the required ground clearances. The cable suspension strand should also be supported at one or more points in the span by the catenary suspension strand. The catenary suspension strand should be attached to the long span poles at locations above the cable suspension strand. The separation between the cable suspension strand and the catenary suspension strand at poles should be such as to allow span attachments to the catenary and support points to be in horizontal alignment. The catenary suspension strand is usually attached to the cable suspension strand by means of cable suspension hooks. Figure 11 shows the general features of catenary suspension strand construction.

8.10 When circumstances indicate the use of slack span construction, Figure 12 depicts such construction.

8.11 Cable weights of self-supporting, filled, fiber optic cables by fiber size, core type, and cable construction which should be used for the cable weight factor in determining span lengths for self-supporting fiber optic cables in aerial plant construction projects are given in Tables 8 and 9.

TABLE 8
Cable Weights
Self-Supporting, Filled Fiber Optic Cables
Multiple Loose Tube Core

	Cable Weights lb/ft (kg/m)	
Fiber Sizes	Nonarmored	Armored
2 - 72	0.25 (0.37)	0.32 (0.48)
74 - 84	0.27 (0.40)	0.34 (0.51)
86 - 96	0.28 (0.42)	0.36 (0.54)
98 - 108	0.30 (0.45)	0.38 (0.57)
110 - 120	0.31 (0.46)	0.40 (0.60)
122 - 132	0.33 (0.49)	0.42 (0.62)
134 - 144	0.35 (0.52)	0.45 (0.67)

TABLE 9
Cable Weights
Self-Supporting, Filled Fiber Optic Cables
Central Core Tube

	Cable Weights lb/ft (kg/m)	
Fiber Sizes	Nonarmored	Armored
2 - 48	0.08 (0.12)	0.12 (0.18)
50 - 96	0.13 (0.19)	0.18 (0.27)

8.12 For self-supporting, filled, fiber optic cables, recommended span length limits for poles of various lengths on level ground which will provide 14 ft (4.3 m) of final unloaded ground clearance at 60°F (15.6°C) for cables in the three storm loading districts referenced in Section 25 of the latest edition of NESC should be obtained from fiber optic cable manufacturers.

9. POLE GUYING

9.1 Guying of poles may be necessary in certain situations to provide additional strength to the pole to sustain the longitudinal load from the wind pressure, the weight of the cable, and the weight of the suspension strand, etc.

9.2 RUS TE&CM Section 650, Guy and Anchors on Wire and Cable Lines, should be consulted when guying of poles is required.

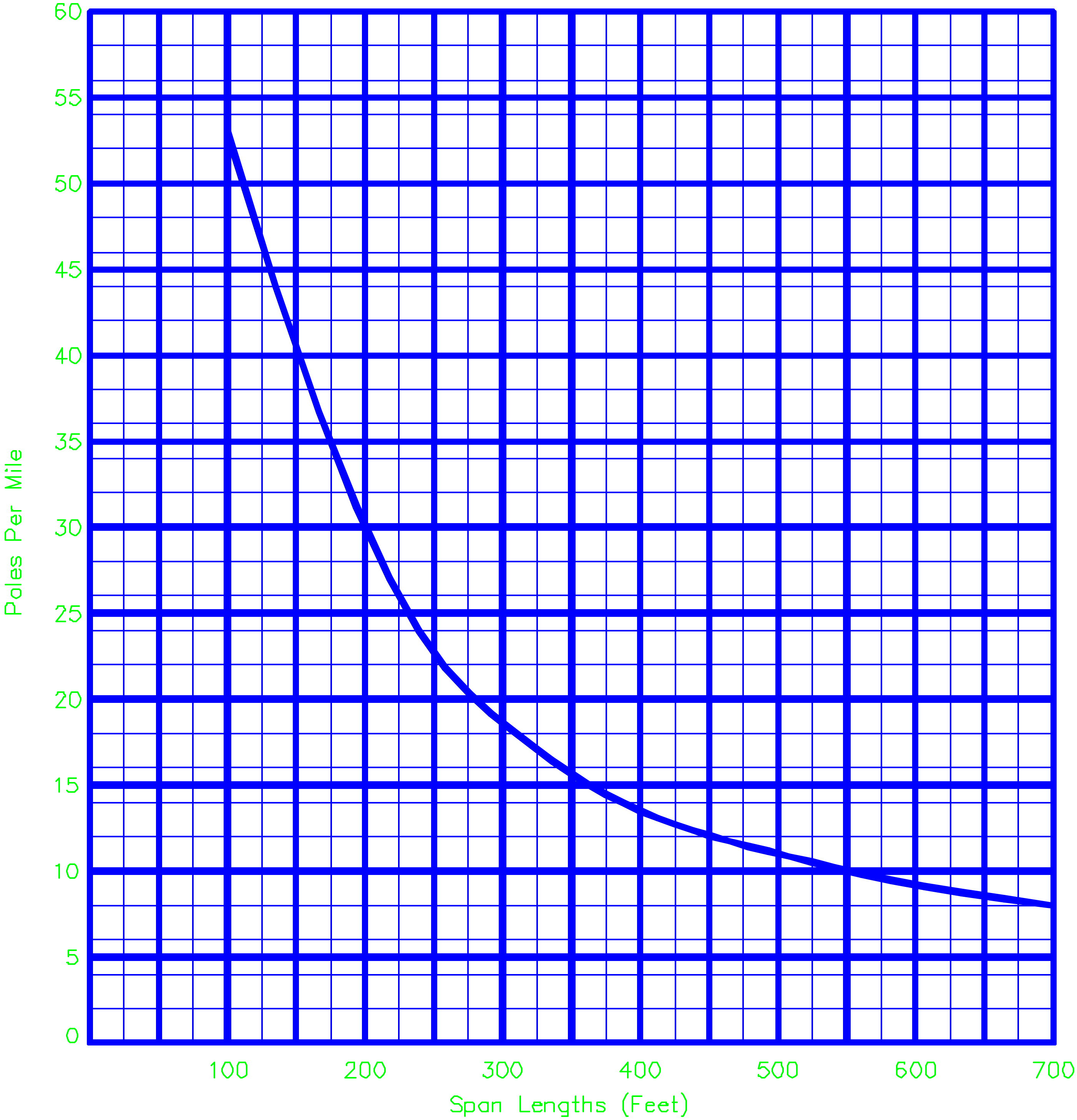
10. SAG

10.1 Locations and amounts of sag at low points in hillside situations and river crossings where support points are at different elevations should be determined in accordance with Figure 13.

10.2 Sag values in percent of midspan sag of level spans at points along a span should be determined from Figure 14. The information in Figure 14 may also be useful in determining separations in a span involving clearances.

FIGURE 1

POLES PER MILE VERSUS SPAN LENGTH

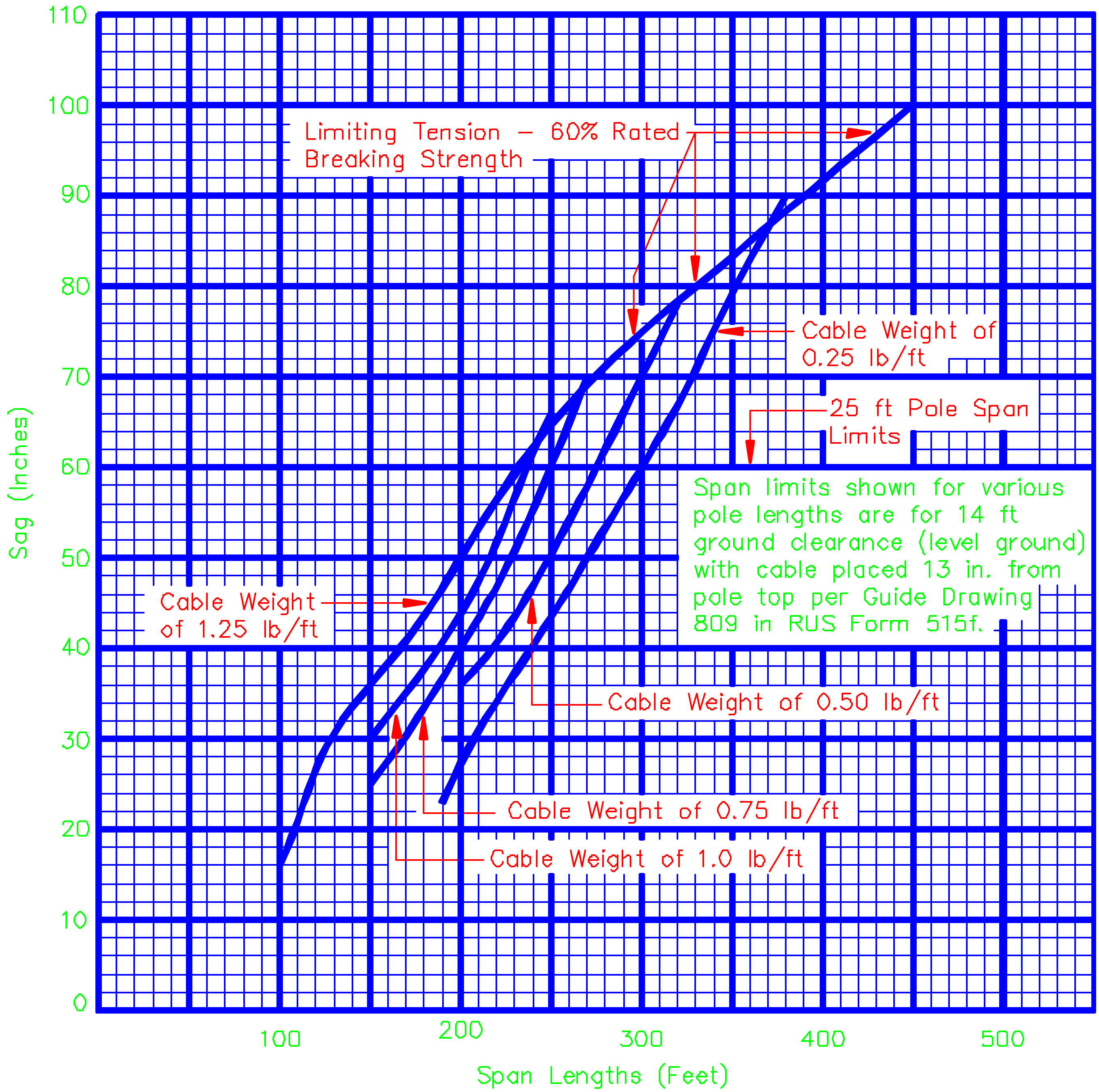


Notes:

1. To convert feet to meters multiply by 0.3048.
2. To convert miles to meters multiply by 1.609.

FIGURE 2

FINAL UNLOADED SAG at 60°F – HEAVY LOADING DISTRICT 6M STRAND

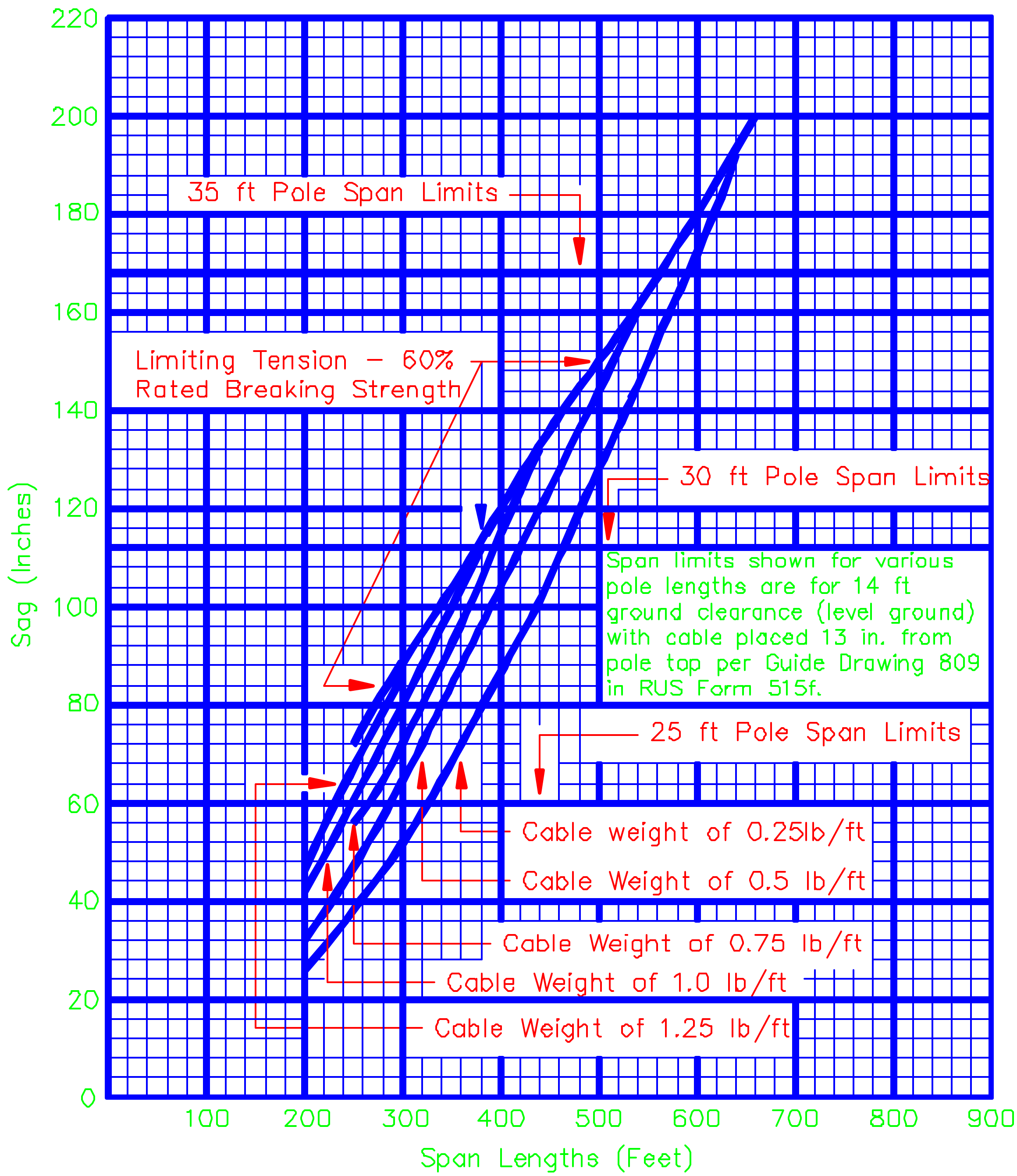


Notes:

1. To convert inches to millimeters multiply by 25.4. 2. To convert feet to meters multiply by 0.3048. 3. To convert lb/ft to kg/m multiply by 1.488. 4. To convert °F to °C use °C = 5/9(°F – 32).

FIGURE 3

FINAL UNLOADED SAG at 60°F – MEDIUM LOADING DISTRICT 6M STRAND

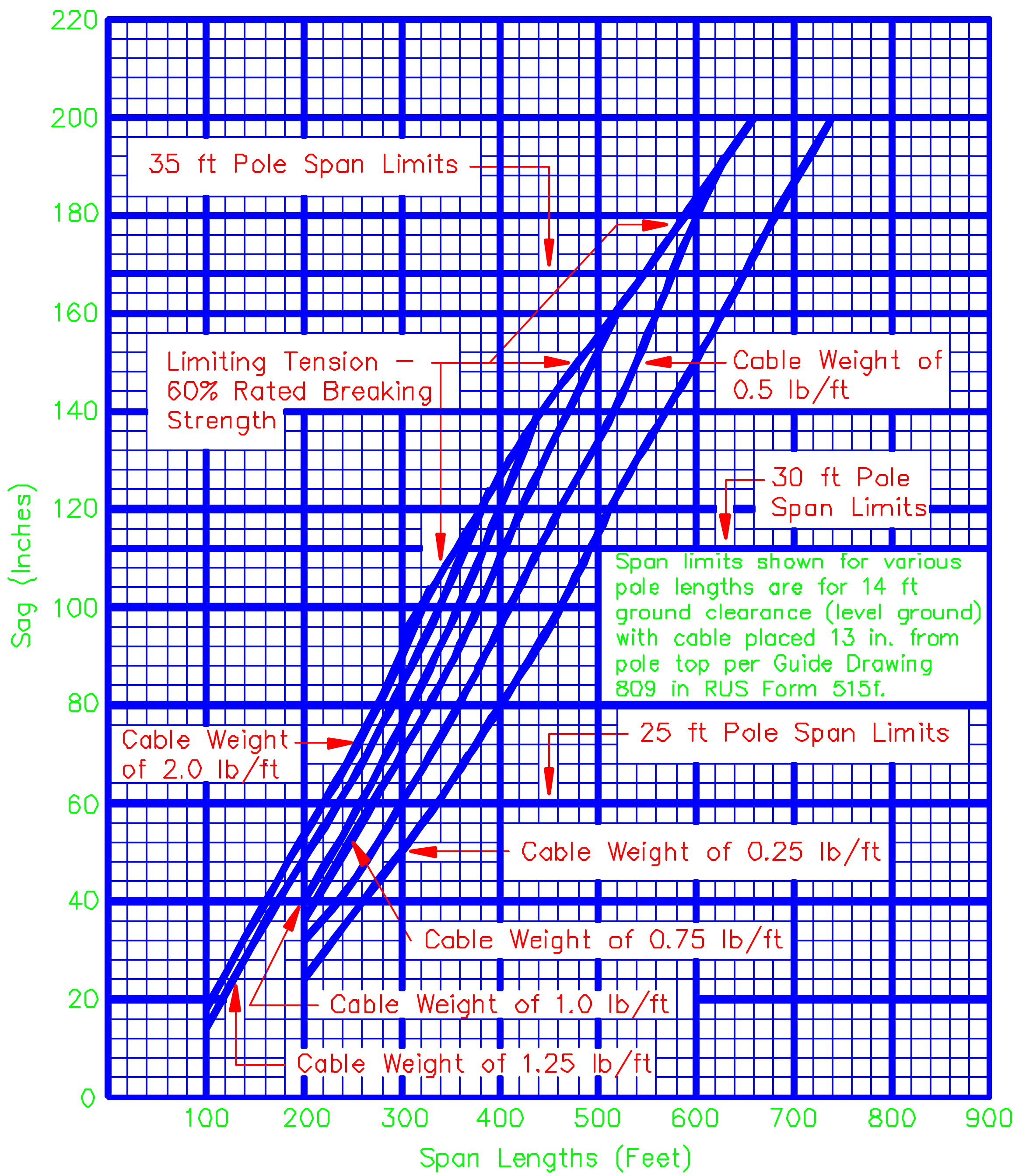


Notes:

1. To convert inches to millimeters multiply by 25.4. 2. To convert feet to meters multiply by 0.3048. 3. To convert lb/ft to kg/m multiply by 1.488. 4. To convert °F to °C use °C = 5/9(°F – 32).

FIGURE 4

FINAL UNLOADED SAG at 60°F – LIGHT LOADING DISTRICT 6M STRAND

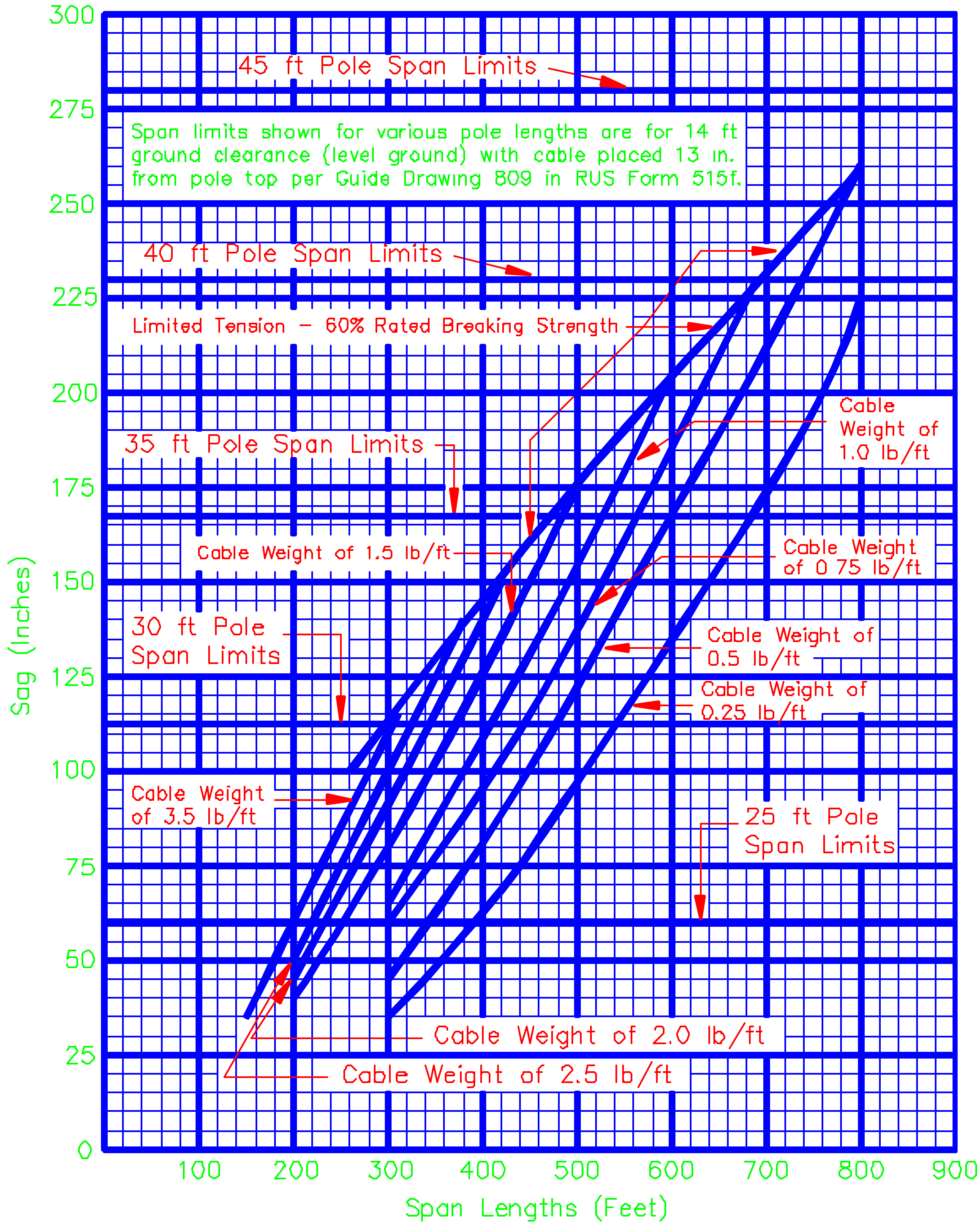


Notes:

1. To convert inches to millimeters multiply by 25.4. 2. To convert feet to to meters multiply by 0.3048. 3. To convert lb/ft to kg/m multiply by 1.488. 4. To convert °F to °C use °C = 5/9(°F – 32).

FIGURE 5

FINAL UNLOADED SAG at 60°F – HEAVY LOADING DISTRICT 10M STRAND

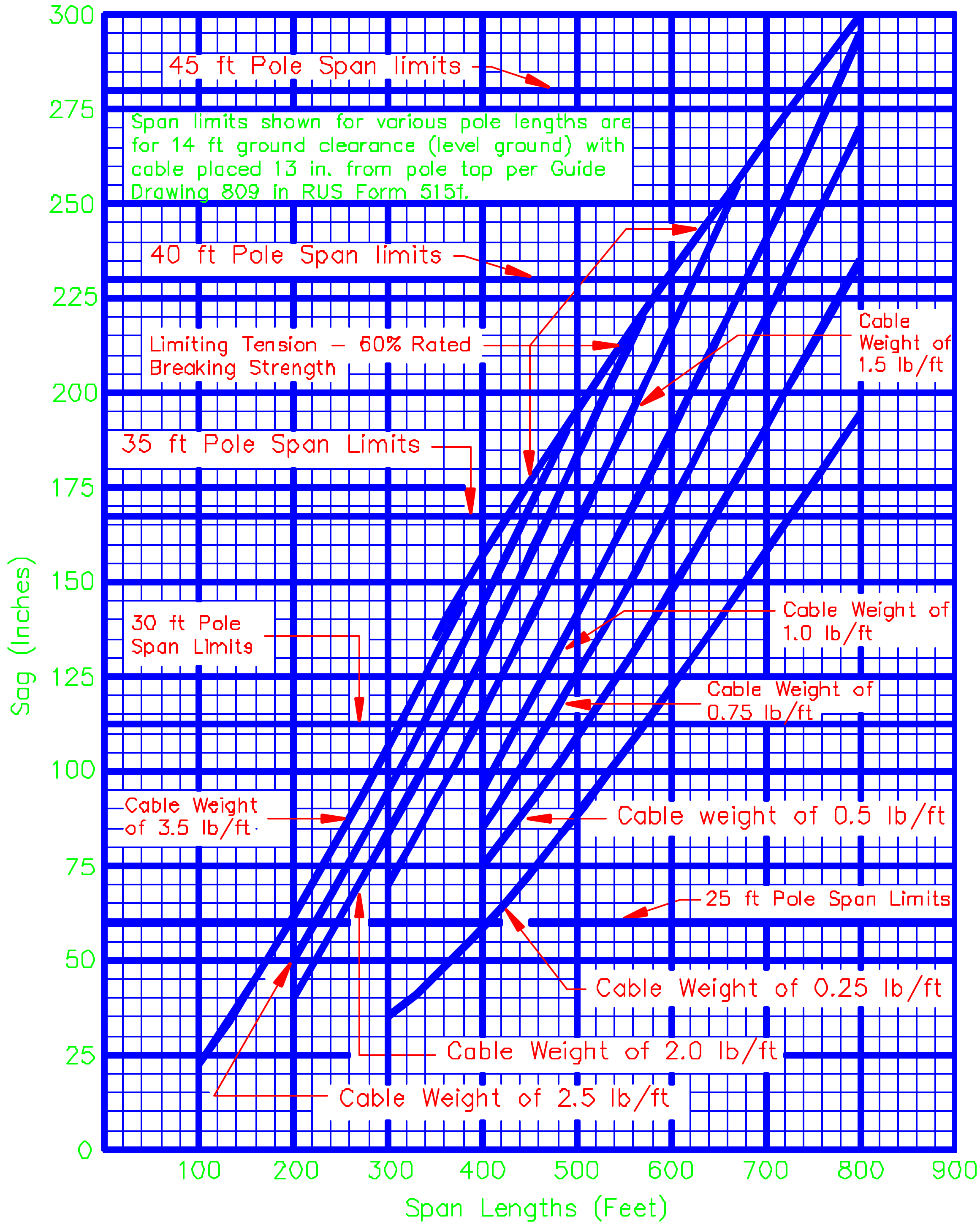


Notes:

1. To convert inches to millimeters multiply by 25.4. 2. To convert feet to meters multiply by 0.3048. 3. To convert lb/ft to kg/m multiply by 1.488. 4. To convert °F to °C use °C = 5/9(°F – 32).

FIGURE 6

FINAL UNLOADED SAG at 60°F – MEDIUM LOADING DISTRICT 10M STRAND

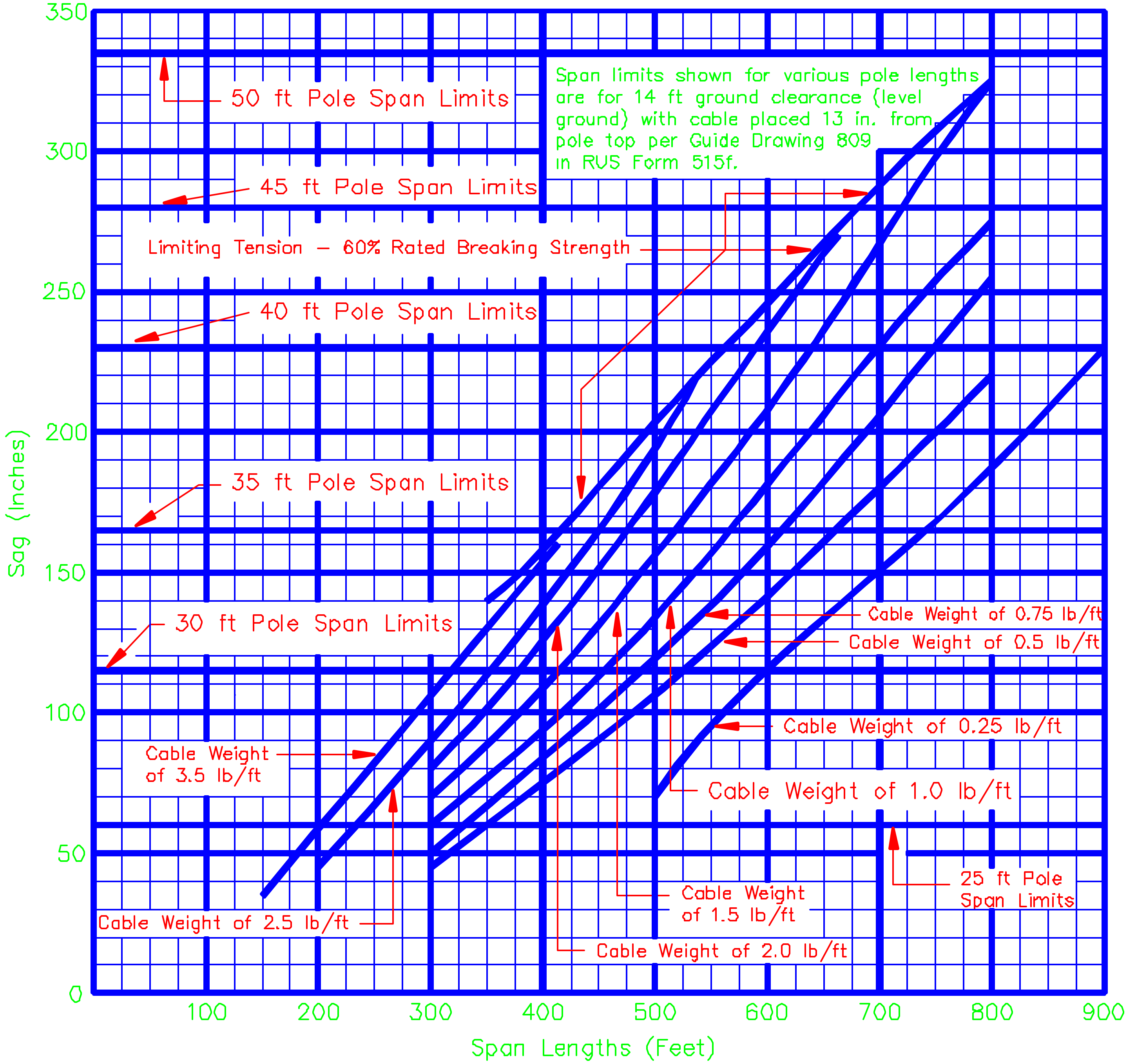


Notes:

1. To convert inches to millimeters multiply by 25.4. 2. To convert feet to meters multiply by 0.3048. 3. To convert lb/ft to kg/m multiply by 1.488. 4. To convert °F to °C use °C = 5/9(°F – 32).

FIGURE 7

FINAL UNLOADED SAG at 60°F – LIGHT LOADING DISTRICT
10M STRAND

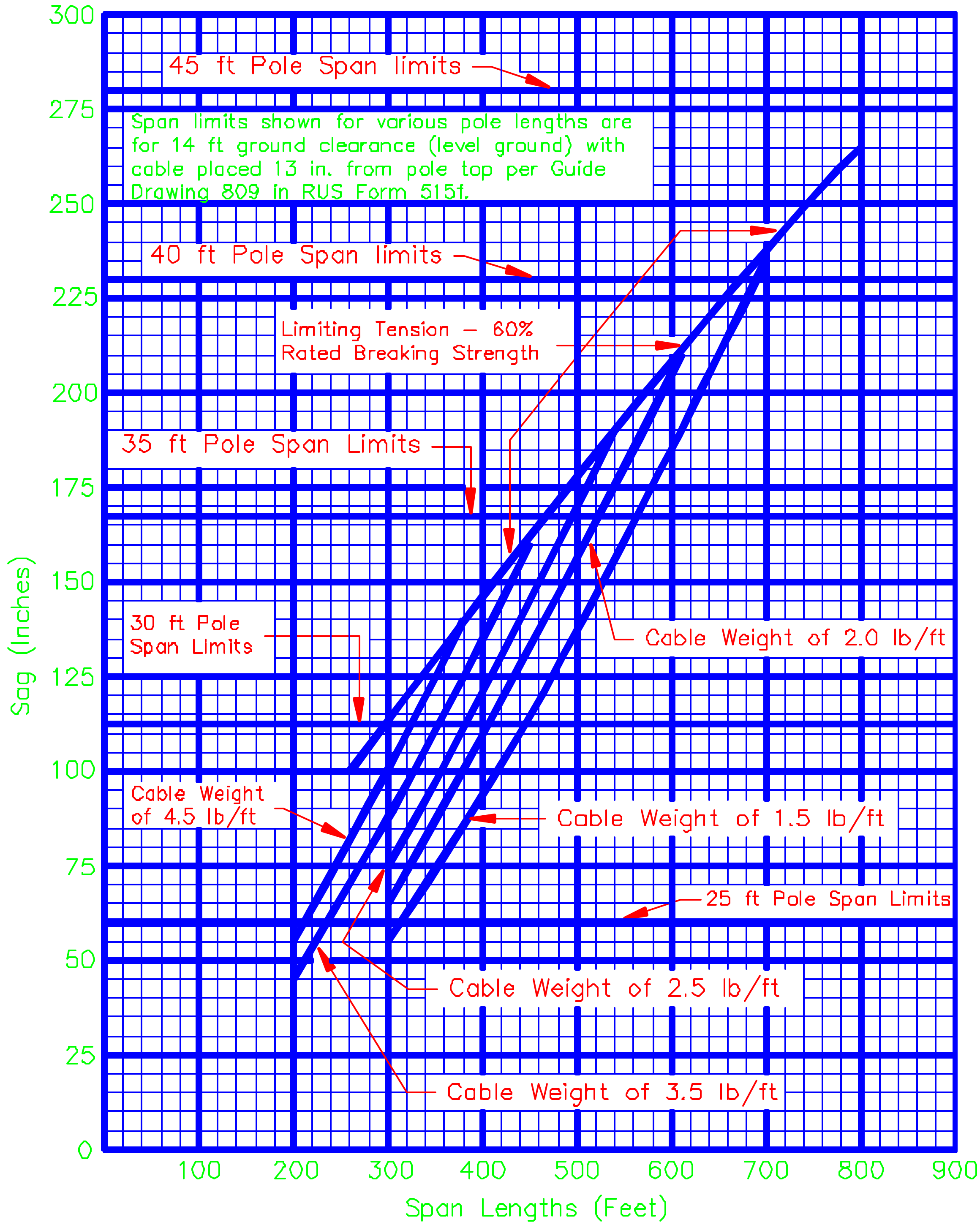


Notes:

1. To convert inches to millimeters multiply by 25.4. 2. To convert feet to meters multiply by 0.3048. 3. To convert lb/ft to kg/m multiply by 1.488. 4. To convert °F to °C use °C = 5/9(°F – 32).

FIGURE 8

FINAL UNLOADED SAG at 60°F – HEAVY LOADING DISTRICT 16M STRAND

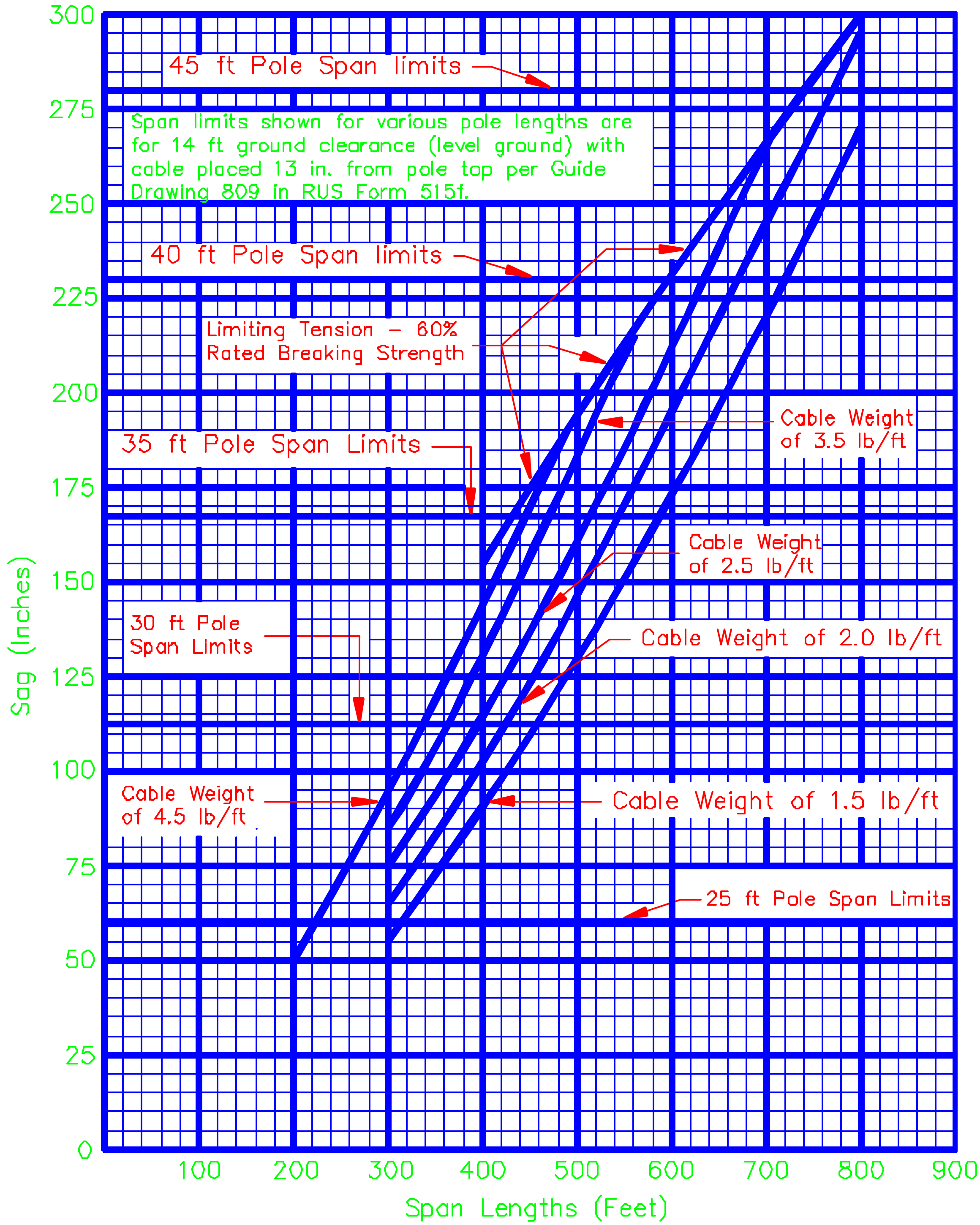


Notes:

1. To convert inches to millimeters multiply by 25.4. 2. To convert feet to meters multiply by 0.3048. 3. To convert lb/ft to kg/m multiply by 1.488. 4. To convert °F to °C use °C = 5/9(°F – 32).

FIGURE 9

FINAL UNLOADED SAG at 60°F – MEDIUM LOADING DISTRICT 16M STRAND

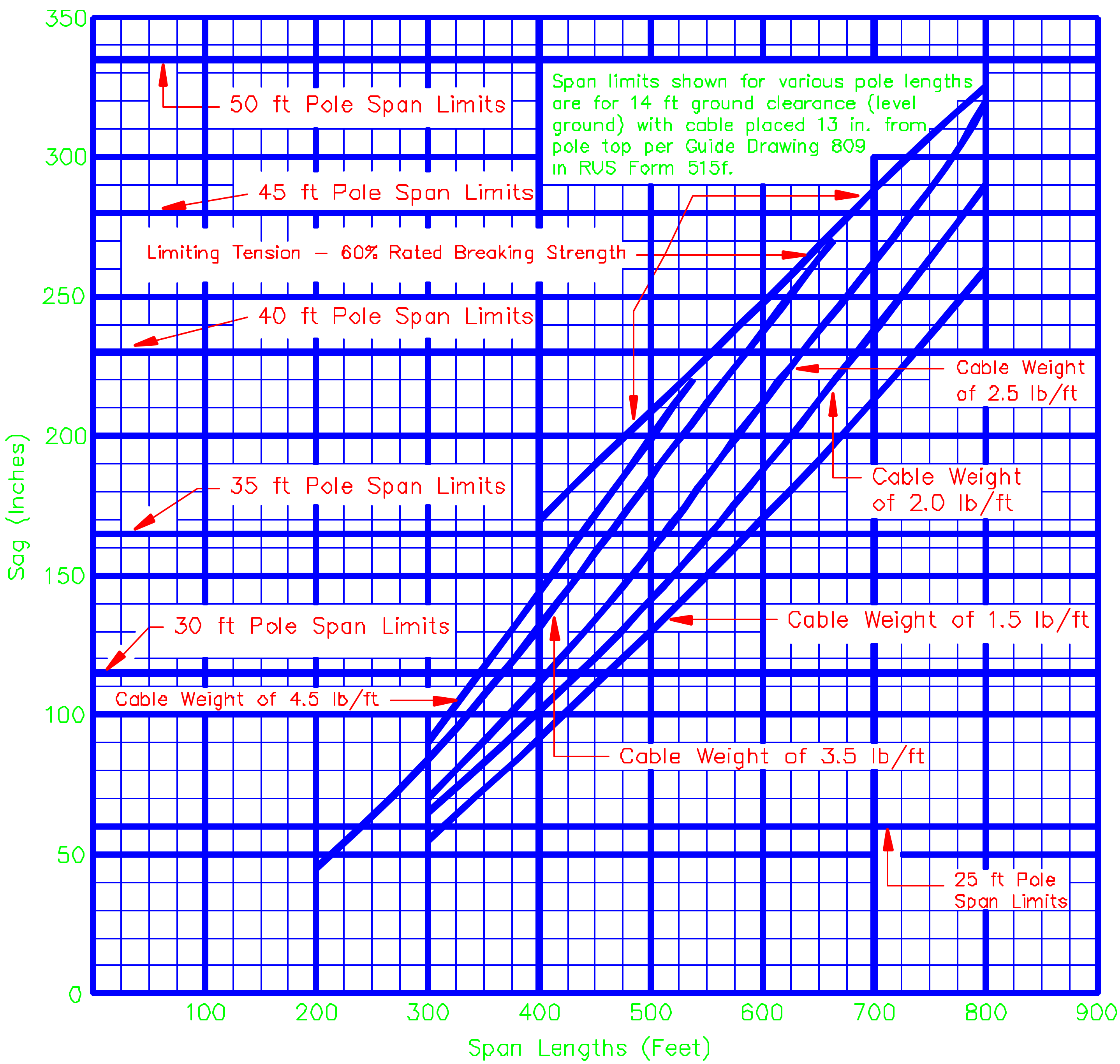


Notes:

1. To convert inches to millimeters multiply by 25.4. 2. To convert feet to to meters multiply by 0.3048. 3. To convert lb/ft to kg/m multiply by 1.488. 4. To convert °F to °C use °C = 5/9(°F – 32).

FIGURE 10

FINAL UNLOADED SAG at 60°F – LIGHT LOADING DISTRICT 16M STRAND



Notes:

1. To convert inches to millimeters multiply by 25.4. 2. To convert feet to meters multiply by 0.3048. 3. To convert lb/ft to kg/m multiply by 1.488. 4. To convert °F to °C use °C = 5/9(F – 32).

FIGURE 11

CATENARY SUSPENSION STRAND CONSTRUCTION
GENERAL FEATURES

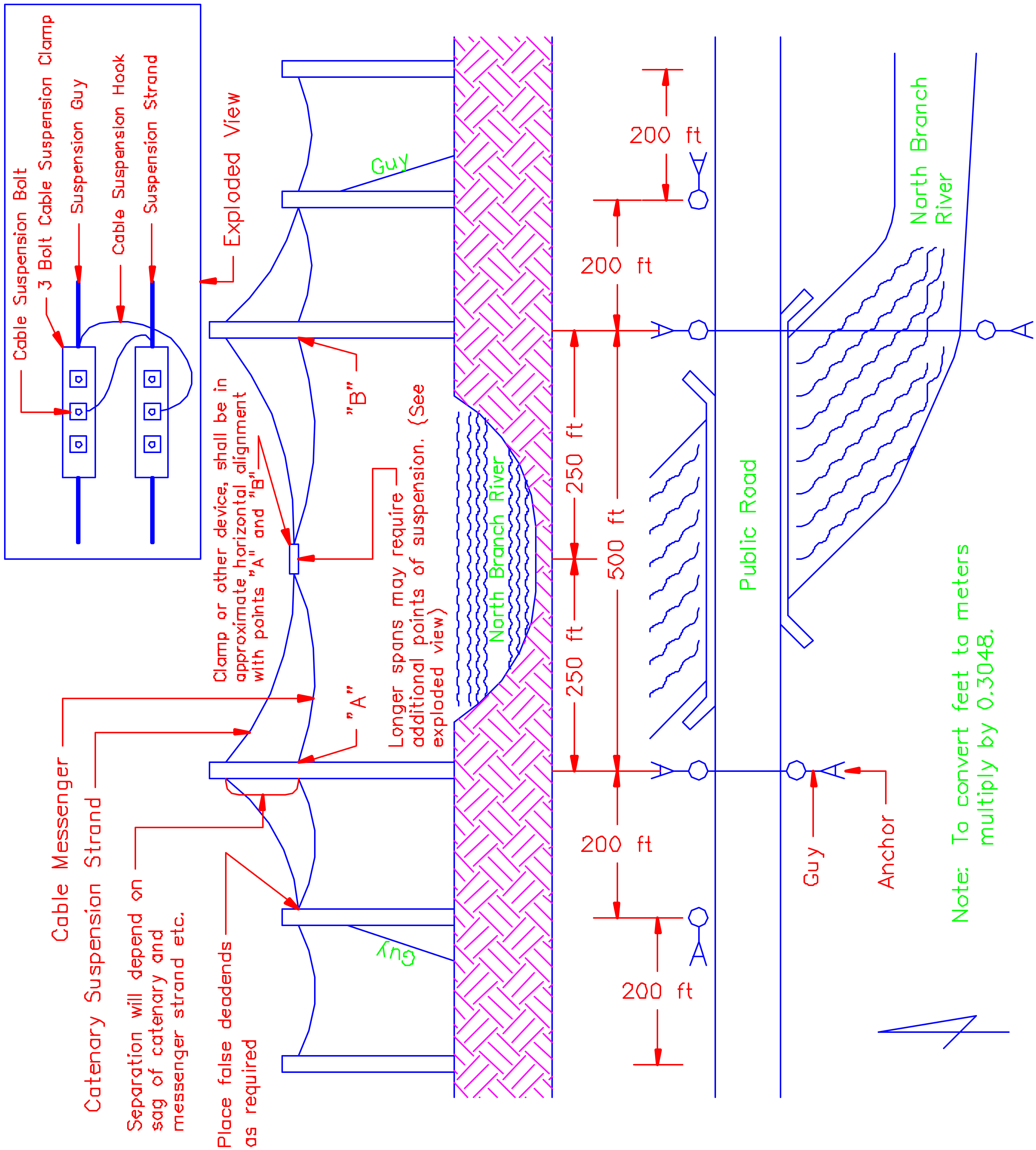


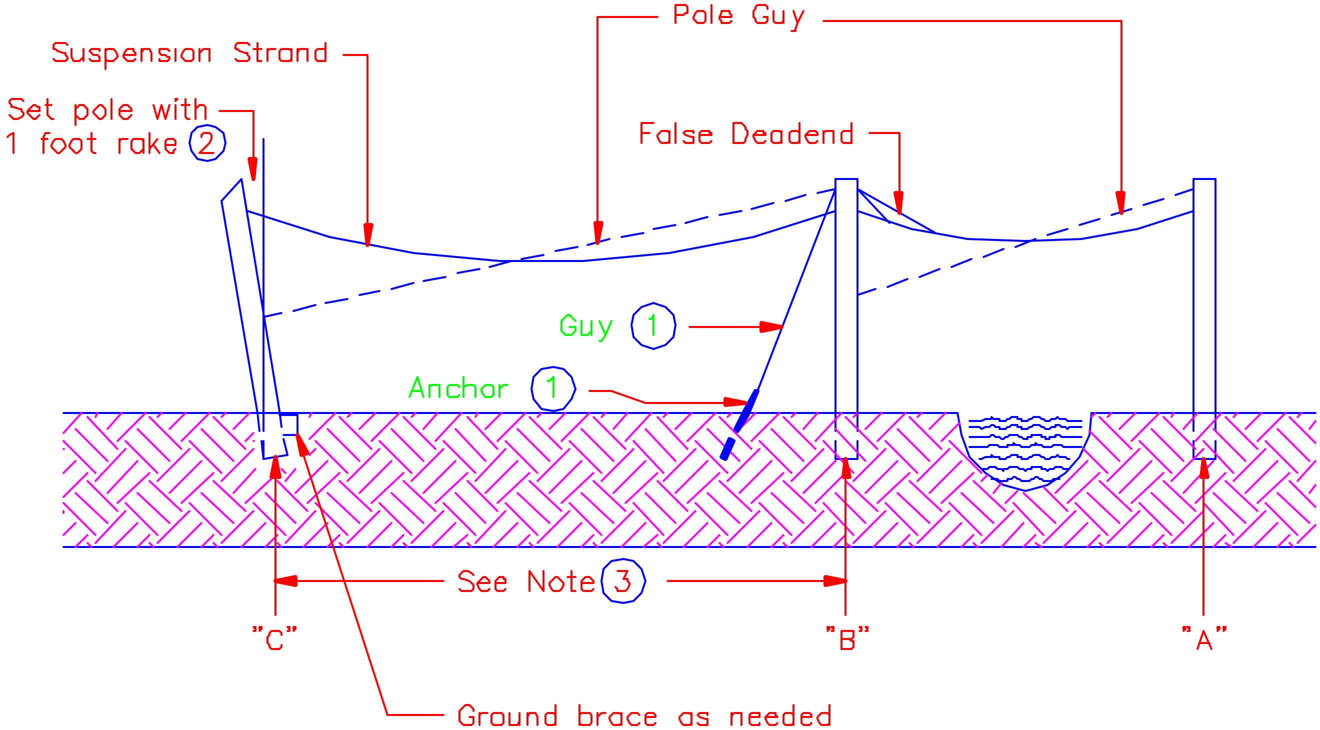
FIGURE 12
SLACK SPAN CONSTRUCTION EXAMPLE

Initial Strand Tension

Strand	Span (ft)	Tension (lbf) at 100°F	60°F	20°F
6M	100	500	800	1100
10M	75	600	1000	1400

Initial Sag With Cable in Place

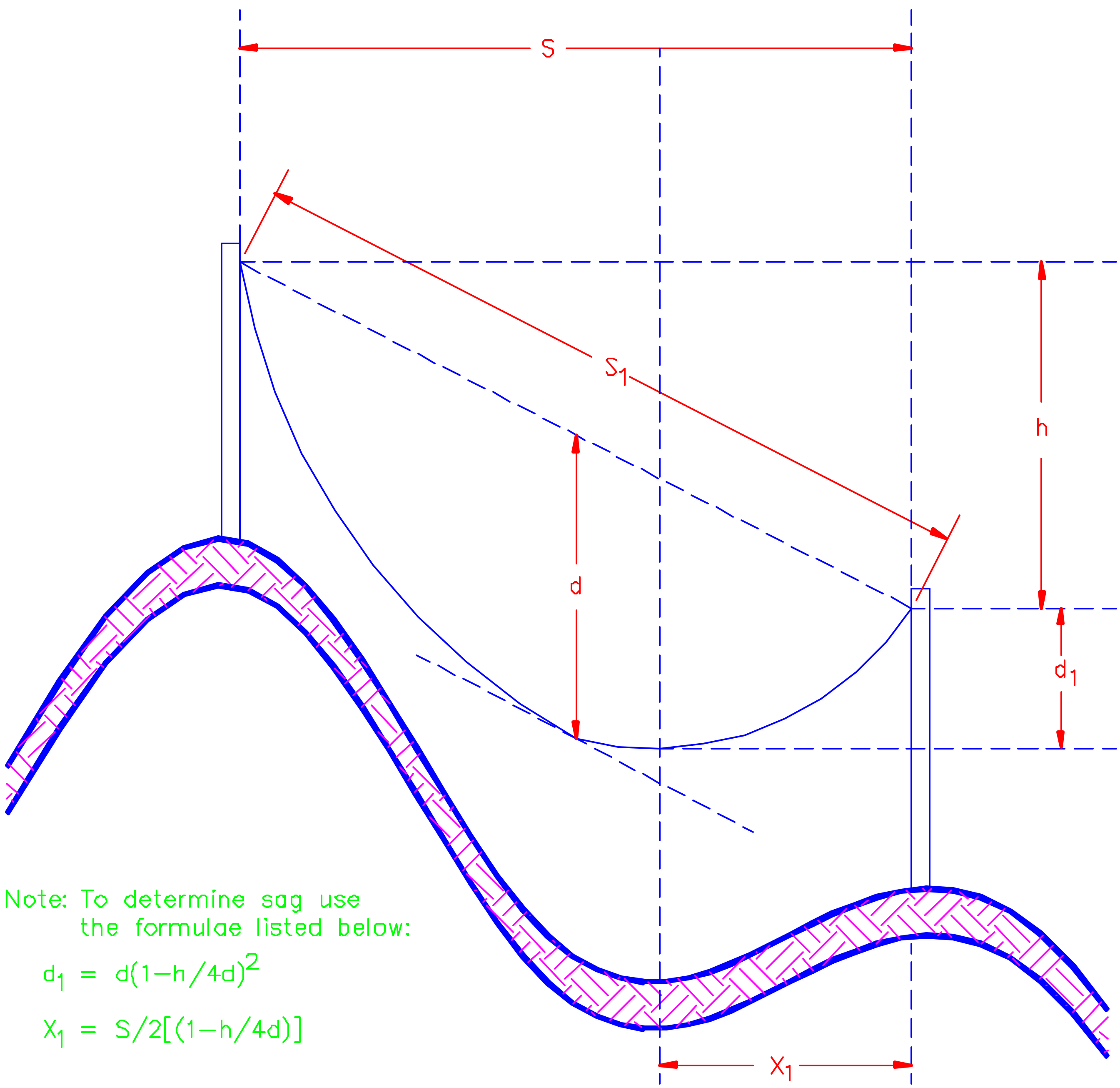
Strand	Max. Cable Weight (lb/ft)	Span (ft)	Sag (in.)
6M	2.25	100	38
10M	5.00	50	27
10M	5.00	75	38



Notes:

1. If unable to place guy and anchor at pole "B," place pole guys as indicated above from pole "A" to pole "B" and from Pole "B" to pole "C."
2. For 6M strand use Class 2 poles and for 10M strand use Class 1 poles.
3. Span lengths for 6M and 10M strands should not exceed a maximum length of 100 feet and 75 feet, respectively.
4. To convert feet to meters multiply by 0.3048.
5. To convert inches to millimeters multiply by 25.4.
6. To convert °F to °C use °C = 5/9(°F − 32).
7. To convert lbf to Newtons (N) multiply by 4.448.
8. To convert lb/ft to kg/m multiply by 1.488.

FIGURE 13
DETERMINATION OF MAXIMUM SAG POINT



Note: To determine sag use the formulae listed below:

$d_1 = d(1-h/4d)^2$

$X_1 = S/2[(1-h/4d)]$

FIGURE 14

CATENARY CURVE FOR DETERMINING THE SAG AT ANY POINT IN A LEVEL SPAN