UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Utilities Service

BULLETIN 1726C-115

SUBJECT: Checking Sag in a Conductor by the Return Wave Method

TO: RUS Electric Borrowers and RUS Electric Staff

EFFECTIVE DATE: Date of Approval

EXPIRATION DATE: Indefinite

OFFICE OF PRIMARY INTEREST: Electric Staff Division

PREVIOUS INSTRUCTIONS: This revised bulletin replaces RUS Bulletin 1726C-115, “Checking Sag in a Conductor by the Return Wave Method,” issued October 20, 1992.

FILING INSTRUCTIONS: Discard RUS Bulletin 1726C-115, dated October 20, 1992, and replace with this revised issue. This bulletin is available on the Internet via the RUS electric web site: www.usda.gov/rus/electric.

PURPOSE: This guide publication presents a convenient and practical method for checking sag in a conductor regardless of span length, tension, size or type of the conductor.

/s/ BDS, Jr. *09/24/98*

Assistant Administrator
Electric Program

Date

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ABBREVIATIONS

RUS Rural Utilities Service

INDEX:

1. INTRODUCTION

1.1 This bulletin describes a convenient method for checking sag in a conductor. This method has been used extensively in checking sag in conductors on RUS borrowers' systems.

2. DISCUSSION

2.1 The return wave method of checking the sag in a conductor is applicable regardless of the span length, tension, size or type of conductor. The time required for a wave initiated on a conductor suspended in air between two fixed supports to traverse between the supports is dependent on the amount of conductor sag. A conductor wave originating at one support will travel to the next support where it will be reflected back to the point of origin where it will again be reflected back to the adjacent support and the cycle repeats. This cyclic action continues until the wave is eventually damped out.

2.2 The relationship between the time required for a conductor wave to travel a number of times between supports and the conductor's sag is given by the equation:

$$\mathbf{D} = \mathbf{48.3}\left[\frac{\mathbf{T}}{\mathbf{2N}}\right]^2 \qquad (1)$$

Where:
D = conductor sag in inches
T = time in seconds
N = number of return waves counted

The Time-Sag Table on pages 5 & 6 was calculated from the above equation.

To convert from inches to millimeters use Formula (2) as given by the equation:

$$\mathbf{X} = \mathbf{25.4D} \qquad (2)$$

Where:
D = conductor sag in inches
X = conductor sag in millimeters

2.3 A wave may be initiated in a conductor close to a support by striking the conductor or by throwing a light, dry, nonmetallic rope or cord over the conductor and pulling the conductor down strongly and quickly releasing the conductor (cord). The return wave arrival may be felt by placing a finger on the conductor if the striking method is used, or if a cord is used, the return wave arrival may be felt in the cord by maintaining light tension on the conductor.

2.4 For an accurate determination of sag, it is important that the correct number of return waves be selected on the Time-Sag Table. The table was prepared for sags corresponding to 3, 5, 10, and 15 return waves. The choice of the number of return waves depends principally upon the span length and size of conductor. For long spans and large conductors, the number of return waves that can be accurately counted is less than for short spans and small conductors. The largest number of return waves should be used consistent with the conditions encountered as this minimizes errors in recording time.

2.5 The wave initiating impulse is not counted as a return wave. A stop watch is started when the wave initiating impulse is applied and stopped immediately as the last of the number of return waves of 3, 5, 10, or 15 as previously selected is received.

Satisfactory results cannot be obtained when the conductor is in motion as a result of other stimuli. Conductor movement, due to wind or craftspeople working on the line, makes it difficult to count the number of return waves. Additionally, satisfactory results cannot be obtained if any objects, such as tree branches, are in contact with the conductor in the span being checked.

2.6 A sufficient number of tests should be made in each span until at least three equal readings are obtained.

Example:

A wave is initiated on a conductor span and a time of 14.1 seconds is measured upon receipt of the 10^{th} return wave. From formula (1) or from the Time Sag Table, it can be seen that the conductor sag is 24 in. (610 mm).

TIME SAG TABLE

Sag (Inches)	Return of Wave				Sag (Inches)	Return of Wave			
	3rd Time (Sec.)	5th Time (Sec.)	10th Time (Sec.)	15th Time (Sec.)		3rd Time (Sec.)	5th Time (Sec.)	10th Time (Sec.)	15th Time (Sec.)
5	1.9	3.2	6.4	9.7	55	6.4	10.7	21.3	32.0
6	2.1	3.5	7.0	10.6	56	6.5	10.8	21.5	32.3
7	2.3	3.8	7.6	11.4	57	6.5	10.9	21.7	32.6
8	2.4	4.1	8.1	12.2	58	6.6	11.0	21.9	32.9
9	2.6	4.3	8.6	13.0	59	6.6	11.1	22.1	33.2
10	2.7	4.6	9.1	13.7	60	6.7	11.1	22.3	33.4
11	2.9	4.8	9.5	14.3	61	6.7	11.2	22.5	33.7
12	3.0	5.0	10.0	15.0	62	6.8	11.3	22.7	34.0
13	3.1	5.2	10.4	15.6	63	6.9	11.4	22.8	34.3
14	3.2	5.4	10.8	16.2	64	6.9	11.5	23.0	34.5
15	3.3	5.6	11.1	16.7	65	7.0	11.6	23.2	34.8
16	3.5	5.8	11.5	17.3	66	7.0	11.7	23.4	35.1
17	3.6	5.9	11.9	17.8	67	7.1	11.8	23.6	35.3
18	3.7	6.1	12.2	18.3	68	7.1	11.9	23.7	35.6
19	3.8	6.3	12.5	18.8	69	7.2	12.0	23.9	35.9
20	3.9	6.4	12.9	19.3	70	7.2	12.0	24.1	36.1
21	4.0	6.6	13.2	19.8	71	7.3	12.1	24.2	36.4
22	4.0	6.7	13.5	20.2	72	7.3	12.2	24.4	36.6
23	4.1	6.9	13.8	20.7	73	7.4	12.3	24.6	36.9
24	4.2	7.0	14.1	21.1	74	7.4	12.4	24.8	37.1
25	4.3	7.2	14.4	21.6	75	7.5	12.5	24.9	37.4
26	4.4	7.3	14.7	22.0	76	7.5	12.5	25.1	37.6
27	4.5	7.5	15.0	22.4	77	7.6	12.6	25.3	37.9
28	4.6	7.6	15.2	22.8	78	7.6	12.7	25.4	38.1
29	4.6	7.7	15.5	23.2	79	7.7	12.8	25.6	38.4
30	4.7	7.9	15.8	23.6	80	7.7	12.9	25.7	38.6
31	4.8	8.0	16.0	24.0	81	7.8	13.0	25.9	38.9
32	4.9	8.1	16.3	24.4	82	7.8	13.0	26.1	39.1
33	5.0	8.3	16.5	24.8	83	7.9	13.1	26.2	39.3
34	5.0	8.4	16.8	25.2	84	7.9	13.2	26.4	39.6
35	5.1	8.5	17.0	25.5	85	8.0	13.3	26.5	39.8
36	5.2	8.6	17.3	25.9	86	8.0	13.3	26.7	40.0
37	5.3	8.8	17.5	26.3	87	8.1	13.4	26.8	40.3
38	5.3	8.9	17.7	26.6	88	8.1	13.5	27.0	40.5
39	5.4	9.0	18.0	27.0	89	8.1	13.6	27.1	40.7
40	5.5	9.1	18.2	27.3	90	8.2	13.7	27.3	41.0
41	5.5	9.2	18.4	27.6	91	8.2	13.7	27.5	41.2
42	5.6	9.3	18.7	28.0	92	8.3	13.8	27.6	41.4
43	5.7	9.4	18.9	28.3	93	8.3	13.9	27.8	41.6
44	5.7	9.5	19.1	28.6	94	8.4	14.0	27.9	41.9
45	5.8	9.7	19.3	29.0	95	8.4	14.0	28.0	42.1
46	5.9	9.8	19.5	29.3	96	8.5	14.1	28.2	42.3
47	5.9	9.9	19.7	29.6	97	8.5	14.2	28.3	42.5
48	6.0	10.0	19.9	29.9	98	8.5	14.2	28.5	42.7
49	6.0	10.1	20.1	30.2	99	8.6	14.3	28.6	43.0
50	6.1	10.2	20.3	30.5	100	8.6	14.4	28.8	43.2
51	6.2	10.3	20.6	30.8	101	8.7	14.5	28.9	43.4
52	6.2	10.4	20.8	31.1	102	8.7	14.5	29.1	43.6
53	6.3	10.5	21.0	31.4	103	8.8	14.6	29.2	43.8
54	6.3	10.6	21.1	31.7	104	8.8	14.7	29.3	44.0

TIME SAG TABLE (con't.)

Sag (Inches)	Return of Wave 3rd Time (Sec.)	5th Time (Sec.)	10th Time (Sec.)	15th Time (Sec.)	Sag (Inches)	Return of Wave 3rd Time (Sec.)	5th Time (Sec.)	10th Time (Sec.)	15th Time (Sec.)
105	8.8	14.7	29.5	44.2	155	10.7	17.9	35.8	53.7
106	8.9	14.8	29.6	44.4	156	10.8	18.0	35.9	53.9
107	8.9	14.9	29.8	44.7	157	10.8	18.0	36.1	54.1
108	9.0	15.0	29.9	44.9	158	10.9	18.1	36.2	54.3
109	9.0	15.0	30.0	45.1	159	10.9	18.1	36.3	54.4
110	9.1	15.1	30.2	45.3	160	10.9	18.2	36.4	54.6
111	9.1	15.2	30.3	45.5	161	11.0	18.3	36.5	54.8
112	9.1	15.2	30.5	45.7	162	11.0	18.3	36.6	54.9
113	9.2	15.3	30.6	45.9	163	11.0	18.4	36.7	55.1
114	9.2	15.4	30.7	46.1	164	11.1	18.4	36.9	55.3
115	9.3	15.4	30.9	46.3	165	11.1	18.5	37.0	55.4
116	9.3	15.5	31.0	46.5	166	11.1	18.5	37.1	55.6
117	9.3	15.6	31.1	46.7	167	11.2	18.6	37.2	55.8
118	9.4	15.6	31.3	46.9	168	11.2	18.7	37.3	56.0
119	9.4	15.7	31.4	47.1	169	11.2	18.7	37.4	56.1
120	9.5	15.8	31.5	47.3	170	11.3	18.8	37.5	56.3
121	9.5	15.8	31.7	47.5	171	11.3	18.8	37.6	56.4
122	9.5	15.9	31.8	47.7	172	11.3	18.9	37.7	56.6
123	9.6	16.0	31.9	47.9	173	11.4	18.9	37.9	56.8
124	9.6	16.0	32.0	48.1	174	11.4	19.0	38.0	56.9
125	9.7	16.1	32.2	48.3	175	11.4	19.0	38.1	57.1
126	9.7	16.2	32.3	48.5	176	11.5	19.1	38.2	57.3
127	9.7	16.2	32.4	48.6	177	11.5	19.1	38.3	57.4
128	9.8	16.3	32.6	48.8	178	11.5	19.2	38.4	57.6
129	9.8	16.3	32.7	49.0	179	11.6	19.3	38.5	57.8
130	9.8	16.4	32.8	49.2	180	11.6	19.3	38.6	57.9
131	9.9	16.5	32.9	49.4	181	11.6	19.4	38.7	58.1
132	9.9	16.5	33.1	49.6	182	11.6	19.4	38.8	58.2
133	10.0	16.6	33.2	49.8	183	11.7	19.5	38.9	58.4
134	10.0	16.7	33.3	50.0	184	11.7	19.5	39.0	58.6
135	10.0	16.7	33.4	50.2	185	11.7	19.6	39.1	58.7
136	10.1	16.8	33.6	50.3	186	11.8	19.6	39.2	58.9
137	10.1	16.8	33.7	50.5	187	11.8	19.7	39.4	59.0
138	10.1	16.9	33.8	50.7	188	11.8	19.7	39.5	59.2
139	10.2	17.0	33.9	50.9	189	11.9	19.8	39.6	59.3
140	10.2	17.0	34.1	51.1	190	11.9	19.8	39.7	59.5
141	10.3	17.1	34.2	51.3	191	11.9	19.9	39.8	59.7
142	10.3	17.1	34.3	51.4	192	12.0	19.9	39.9	59.8
143	10.3	17.2	34.4	51.6	193	12.0	20.0	40.0	60.0
144	10.4	17.3	34.5	51.8	194	12.0	20.0	40.1	60.1
145	10.4	17.3	34.7	52.0	195	12.1	20.1	40.2	60.3
146	10.4	17.4	34.8	52.2	196	12.1	20.1	40.3	60.4
147	10.5	17.4	34.9	52.3	197	12.1	20.2	40.4	60.6
148	10.5	17.5	35.0	52.5	198	12.1	20.2	40.5	60.7
149	10.5	17.6	35.1	52.7	199	12.2	20.3	40.6	60.9
150	10.6	17.6	35.2	52.9	200	12.2	20.3	40.7	61.0
151	10.6	17.7	35.4	53.0	201	12.2	20.4	40.8	61.2
152	10.6	17.7	35.5	53.2	202	12.3	20.5	40.9	61.4
153	10.7	17.8	35.6	53.4	203	12.3	20.5	41.0	61.5
154	10.7	17.9	35.7	53.6	204	12.3	20.6	41.1	61.7