Southwire

TECHNOLOGY CENTER

Self-Damping Tests of Various "Drake" Conductors

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INTRODUCTION

Laboratory simulation of aeolian vibrations on overhead conductors can provide useful data in determining the degree of resistance of conductors to these types of oscillations. With respect to the conductor itself, this degree of resistance to aeolian vibrations--also called self-damping--can depend on many factors. The temper of the metals used to manufacture the conductor, the shape of the conductor strands, and the manufacturing process itself are just a few examples of factors that impact the self-damping abilities of overhead conductors. The Cofer Technology Center was requested to perform aeolian vibration tests on four distinct sample constructions of 795 kcmil 26/7 "Drake" overhead transmission conductors to determine their self-damping characteristics. These four constructions--each having a galfan steel core--consisted of ACSR, ACSR/TW, ACSS, and ACSS/TW.

SUMMARY OF RESULTS

Overall, the ACSS conductors performed better than the ACSR conductors. In the initial state, the self-damping characteristics of all four constructions were similar up to 20 Hertz. Beyond this point, the ACSS conductors had a power dissipation two to four times that of the ACSR conductors. In the final state, the ACSS conductors stood out even more. The difference increased to five to twenty times between the two constructions. It was difficult to determine whether the ACSS or ACSS/TW had better self-damping capabilities.

PROCEDURE

The self-damping tests were performed in a temperature controlled lab at 22°C ± 1°. The test arrangement consisted of an approximately 33 meter (108 feet) length of the sample conductor extending the entire length of the test span. The conductor was terminated at both ends with quadrant clamps--one end placed in series with a load cell and dead-end tensioning device. A second termination was made using compression blocks, approximately 1.2 meters (4 feet) from each end of the quadrant clamps looking into the span. This resulted in a free span length of 30.5 meters (100 feet) for damping measurements. The electro-dynamic modal shaker used to excite the conductor was placed 0.8 meters (2.6 feet) from the compression block at the same end as the tensioning device. This position along the conductor was located near an antinode, thereby, having a minimal effect on the length of the loop lengths. Low mass plastic fittings, approximately 138 grams, were made to exclusively fit the diameter of each conductor for the attachment of the shaker's armature to the conductor. The combination of the mass of the armature and the plastic fittings translated to less than ten percent of the mass per unit length of each conductor. This light-weight combination helped minimize the possibility of localized damping at the attachment of the armature to the conductor.

The establishment of the test protocol was based on the objective of ascertaining the damping characteristics of the conductors under both initial and final loading conditions. Though the actual design situations and parameters could not be simulated, it was generalized that the following test method would enable practical comparisons between the conductors for the desired objective.

> Test the conductor at 15%, 20% and 30% of its Rated Tensile Strength (RTS). Upon completion of the 30% level, stretch the conductor by raising the tension to 50% RTS and holding for one hour. This stretching is necessary to help facilitate the final loading/unloading conditions of the conductors. Reversing the order, again test the conductors at 30%, 20%, and 15% RTS.

Note that there was no initial conditioning process of the conductor(s). The only conditioning factor involved was allowing the tension among the strands to equalize over a thirty-minute period once the conductor was strung up to the designated tension.

The "Inverse Standing Wave Ratio" (ISWR) test method was the preferred method for testing the conductors. The antinode displacement (double) amplitudes selected for the test were 33/f ($100^{mm}/_{s}$), 67/f ($200^{mm}/_{s}$), and 100/f ($300^{mm}/_{s}$). These values correspond to 0.5, 1.0, and 1.5 times the fatigue limits for aluminum, respectively.

Ideally, it was desired to complete a tension level per testing period to minimize potential changes in the span setup overnight. A minimum of five different modes (loop lengths) per tension level would be tested for each conductor. Modes 4, 8, 12, 16, and 20 were chosen to be tested since they were within the ranges of the frequencies and wind speeds generated by winds classified as causing aeolian vibrations on overhead conductors. The wind speeds indicated in Tables 1-18 are derived from the corresponding test frequencies.

DISCUSSION OF RESULTS

The results for each conductor are presented in order of testing in Tables 1-18 and the corresponding Figures attached in the appendix.

Direct comparisons of the data indicate that the ACSS and ACSS/TW constructions have the higher degree of self-damping capabilities compared to the ACSR and ACSR/TW constructions. With respect to the conductors in their initial states, all four constructions possess relatively similar damping characteristics below 20 Hertz. The power dissipated by each conductor is generally very low--often less than 50 mW. The power dissipation typically increases by as much as two to four times on average at 20 Hertz and higher for the ACSS and ACSS/TW constructions compared to the ACSR and ACSR/TW constructions. Table 1 and its accompanying figure, for example, illustrate this type of behavior.

The damping performance of the four constructions varied considerably after stretching the conductors to allow them to reach their final states. The power dissipated by the ACSS and ACSS/TW constructions compared to the ACSR and ACSR/TW constructions increases by as much as 5-20 times throughout the entire frequency spectrum. The damping of the ACSS and ACSS/TW constructions was so great at 25 Hertz and higher, it became difficult to even measure. In some cases, it was not possible to test the conductor at a desired fifth mode. The notation (2) on the applicable charts for ACSS and ACSS/TW indicate the frequencies at which this problem occurred. The notation (1) on those relevant charts denotes that the conductor birdcaged at that particular mode and possibly lowered the true magnitude of the power dissipated by the conductor. Table 16 and its accompanying figure represent an example of the significant differential of power dissipation between the four constructions, and also, where the problems caused by extreme high self-damping occurred.

The performance of the ACSR and ACSR/TW constructions in their final states compared to the results in their initial states was only slightly higher in some cases. Overall, however, there was not enough change in the magnitudes of the power dissipation to indicate any distinguishable differences. It can be generalized that these two constructions possess relatively low damping capabilities.

It is difficult to discern any drastic performance differences between the ACSS compared to the ACSS/TW and the ACSR compared to ACSR/TW. The ACSR and ACSR/TW constructions appear to mirror image each other with respect to their damping abilities before and after stretching. Overall, the ACSS and the ACSS/TW construction also performed very similarly to each other. It can be noted, however, that the ACSS/TW construction has slightly higher damping capabilities than the ACSS construction after stretching at 15% RTS (Final State). The data collected at 20% RTS before stretching indicates that the ACSS construction performs better than the ACSS/TW construction at approximately 25 Hertz or higher.

CONCLUSIONS

Aeolian vibrations can cause serious problems for an overhead conductor. As discovered in this testing, many factors contribute to level of vibrations.

In an ACSS conductor, the steel core carries the majority of the tension. This is due to the annealing process. The tension in the aluminum strands is usually very low. This means that the conductor's self-damping capabilities are very high. After the conductor is pre-stretched and said to be in its "final state", there is virtually no stresses in the aluminum strands and the steel core bears the full tension. This is clearly seen on the graphs between the initial and final states.

The vibration behavior for the conventional construction versus the trapwire (TW) design were very similar for a given tension and frequency. Normally, if the size increases the self-damping capabilities also increase. In this case, there was only a .098 inch reduction in diameter for the TW design. This was not enough to make a significant difference in the power dissipation.

APPENDIX

Table 1

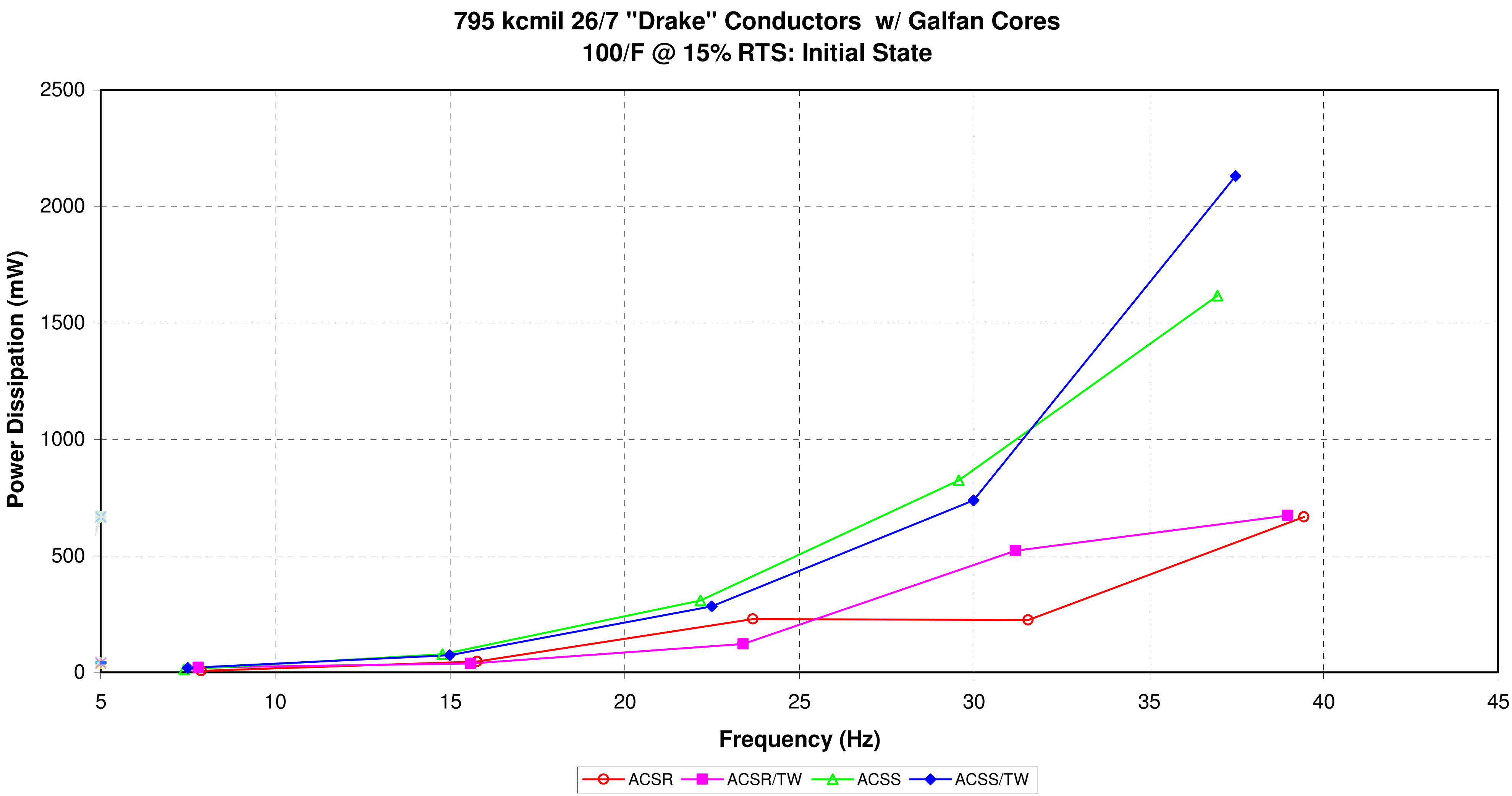
Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
100/F @ 15% RTS: Initial State

ACSR			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.888	7	2.76
8	15.776	46	5.52
12	23.664	228	8.28
16	31.552	224	11.04
20	39.440	666	13.80

ACSR/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.796	21	2.49
8	15.592	38	4.97
12	23.388	122	7.46
16	31.184	523	9.95
20	38.980	673	12.43

ACSS			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.392	13	2.58
8	14.784	78	5.17
12	22.176	308	7.75
16	29.568	825	10.34
20	36.960	1616	12.92

ACSS/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.496	18	2.39
8	14.992	73	4.78
12	22.488	284	7.17
16	29.984	738	9.56
20	37.480	2130	11.95



795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
100/F @ 15% RTS: Initial State
Power Dissipation (mW)
2500
2000
1500
1000
500
0
5
10
15
20
25
30
35
40
45
Frequency (Hz)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 2

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
67/F @ 15% RTS: Initial State

ACSR

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	7.888	1	2.76
8	15.776	21	5.52
12	23.664	80	8.28
16	31.552	149	11.04
20	39.440	199	13.80

ACSR/TW

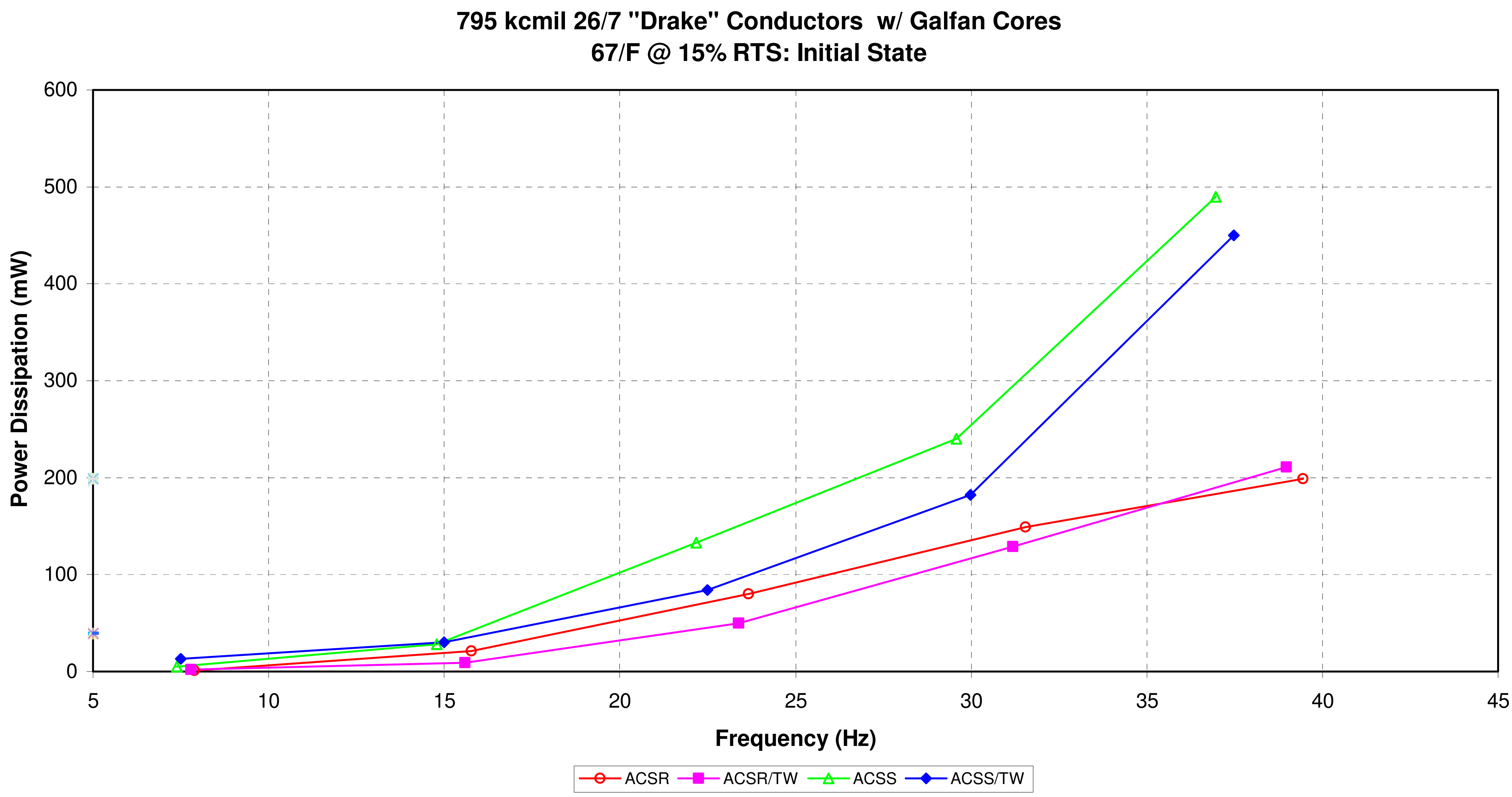
Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	7.796	2	2.49
8	15.592	9	4.97
12	23.388	50	7.46
16	31.184	129	9.95
20	38.980	211	12.43

ACSS

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	7.392	5	2.58
8	14.784	28	5.17
12	22.176	133	7.75
16	29.568	240	10.34
20	36.960	490	12.92

ACSS/TW

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	7.496	13	2.39
8	14.992	30	4.78
12	22.488	84	7.17
16	29.984	182	9.56
20	37.480	450	11.95



795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
67/F @ 15% RTS: Initial State
Power Dissipation (mW)
Frequency (Hz)
0
100
200
300
400
500
600
5
10
15
20
25
30
35
40
45
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 3

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
33/F @ 15% RTS: Initial State

ACSR			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.888	3	2.76
8	15.776	3	5.52
12	23.664	9	8.28
16	31.552	26	11.04
20	39.440	67	13.80

ACSR/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.796	1	2.49
8	15.592	1	4.97
12	23.388	5	7.46
16	31.184	21	9.95
20	38.980	46	12.43

ACSS			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.392	1	2.58
8	14.784	4	5.17
12	22.176	13	7.75
16	29.568	32	10.34
20	36.960	59	12.92

ACSS/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.496	7	2.39
8	14.992	6	4.78
12	22.488	10	7.17
16	29.984	26	9.56
20	37.480	69	11.95

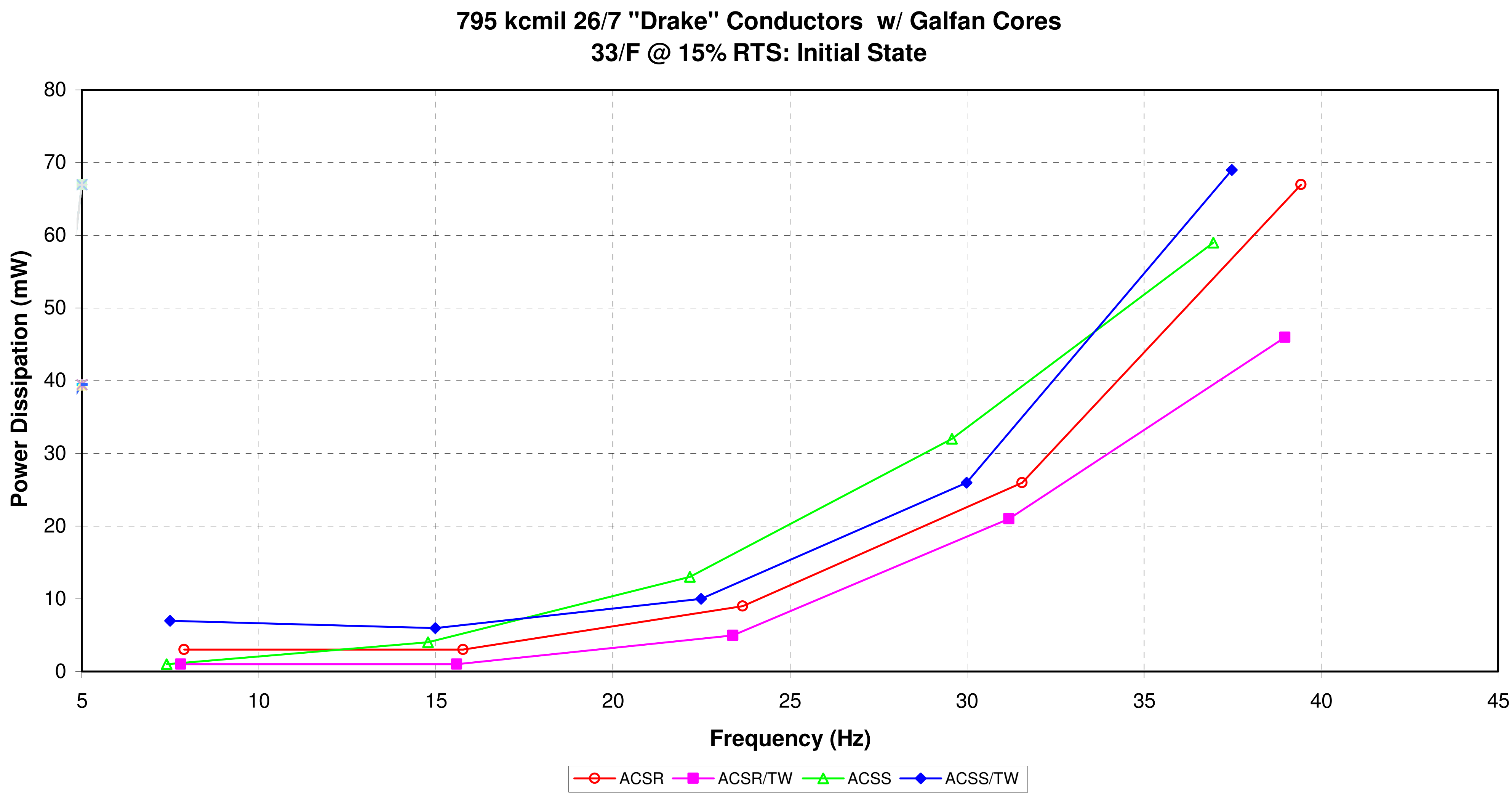

795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
33/F @ 15% RTS: Initial State
Power Dissipation (mW)
0
10
20
30
40
50
60
70
80
5
10
15
20
25
30
35
40
45
Frequency (Hz)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 4

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
100/F @ 20% RTS: Initial State

ACSR

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	8.888	7	3.11
8	17.776	20	6.22
12	26.664	65	9.33
16	35.552	128	12.44
20	44.440	455	15.55

ACSR/TW

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	8.908	6	2.84
8	17.816	36	5.68
12	26.724	60	8.52
16	35.632	219	11.36
20	44.540	303	14.20

ACSS

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	8.196	61	2.86
8	16.392	34	5.73
12	24.588	141	8.59
16	32.784	478	11.46
20	40.980	966	14.32

ACSS/TW

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	8.476	14	2.70
8	16.952	20	5.41
12	25.428	124	8.11
16	33.904	337	10.81
20	42.380	808	13.52

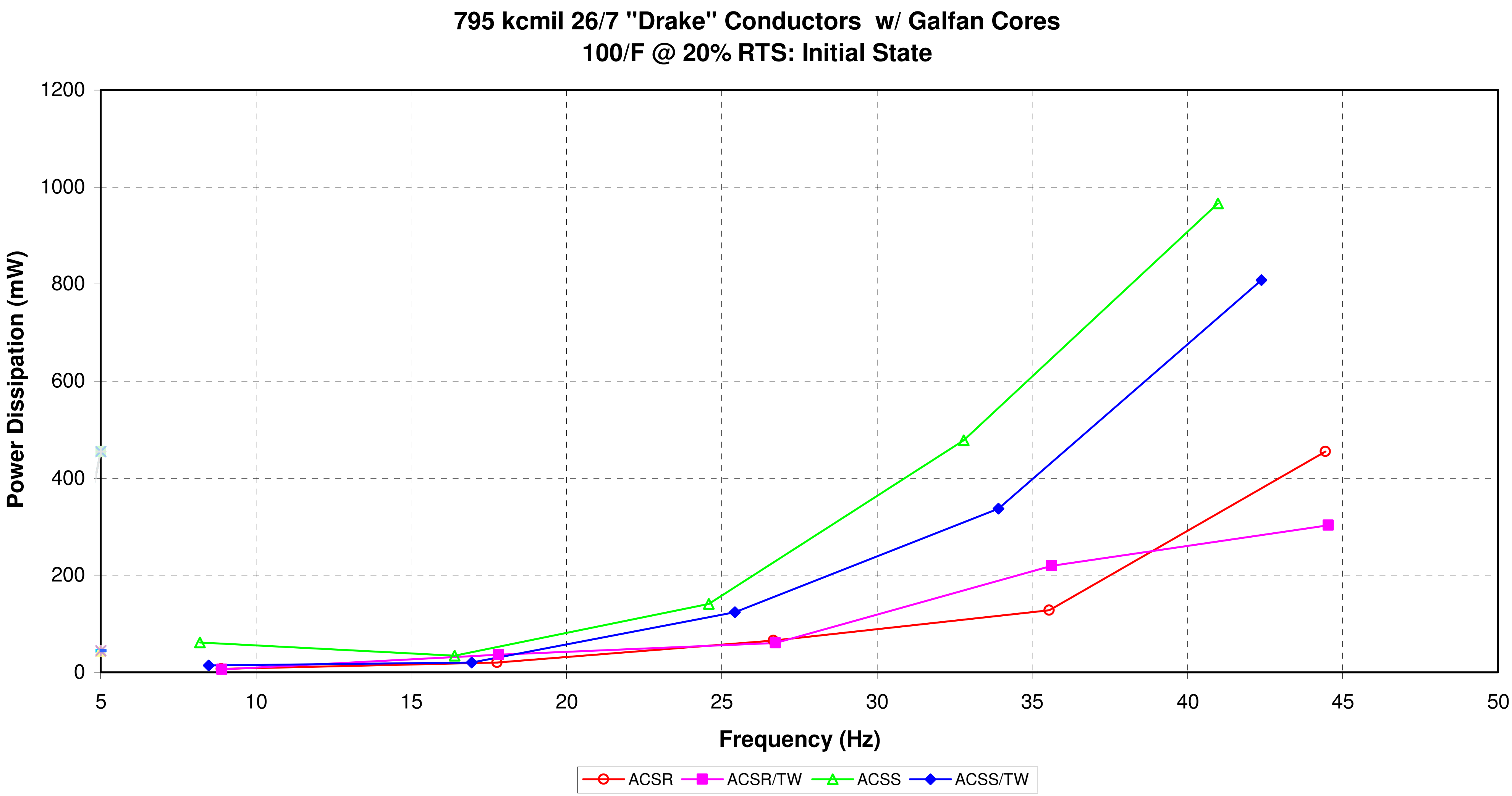

795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
100/F @ 20% RTS: Initial State
Power Dissipation (mW)
1200
1000
800
600
400
200
0
5
10
15
20
25
30
35
40
45
50
Frequency (Hz)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 5

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
67/F @ 20% RTS: Initial State

ACSR

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	8.888	17	3.11
8	17.776	9	6.22
12	26.664	20	9.33
16	35.552	24	12.44
20	44.440	217	15.55

ACSR/TW

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	8.908	2	2.84
8	17.816	6	5.68
12	26.724	17	8.52
16	35.632	65	11.36
20	44.540	215	14.20

ACSS

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	8.196	25	2.86
8	16.392	13	5.73
12	24.588	42	8.59
16	32.784	159	11.46
20	40.980	358	14.32

ACSS/TW

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	8.476	3	2.70
8	16.952	9	5.41
12	25.428	56	8.11
16	33.904	131	10.81
20	42.380	305	13.52

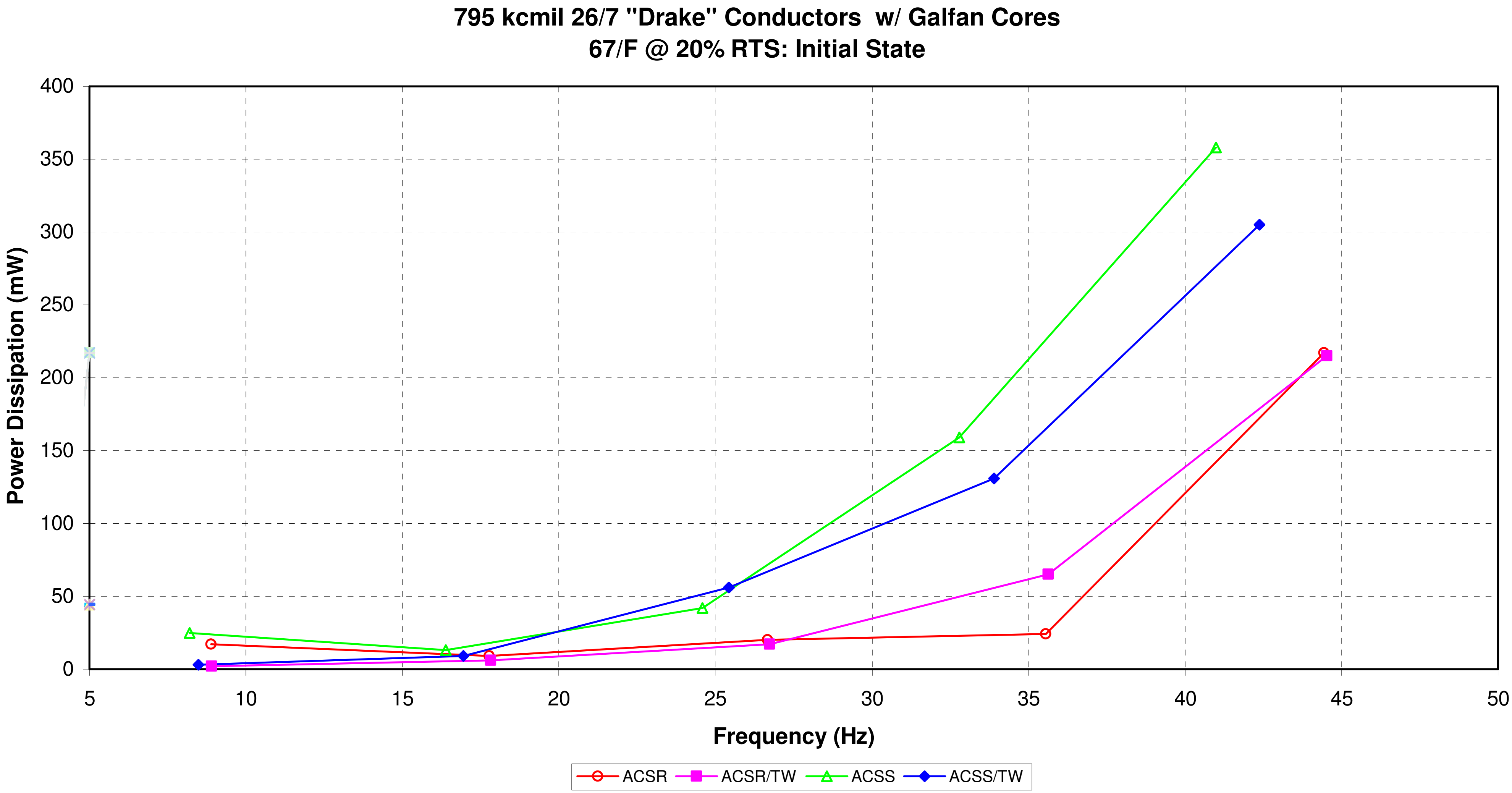

795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
67/F @ 20% RTS: Initial State
Power Dissipation (mW)
400
350
300
250
200
150
100
50
0
5
10
15
20
25
30
35
40
45
50
Frequency (Hz)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 6

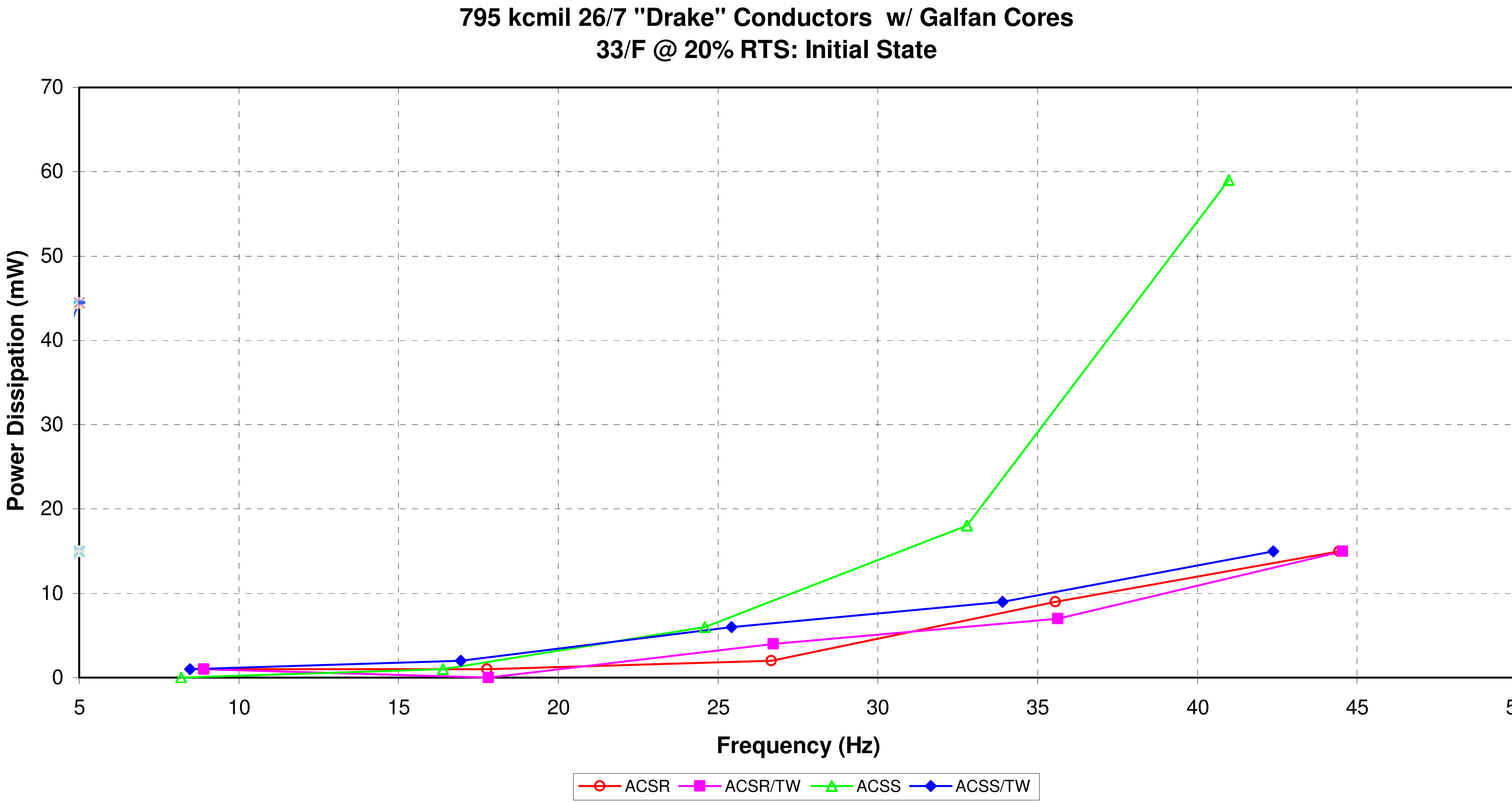
Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
33/F @ 20% RTS: Initial State

ACSR			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	8.888	1	3.11
8	17.776	1	6.22
12	26.664	2	9.33
16	35.552	9	12.44
20	44.440	15	15.55

ACSR/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	8.908	1	2.84
8	17.816	0	5.68
12	26.724	4	8.52
16	35.632	7	11.36
20	44.540	15	14.20

ACSS			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	8.196	0	2.86
8	16.392	1	5.73
12	24.588	6	8.59
16	32.784	18	11.46
20	40.980	59	14.32

ACSS/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	8.476	1	2.70
8	16.952	2	5.41
12	25.428	6	8.11
16	33.904	9	10.81
20	42.380	15	13.52



795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
33/F @ 20% RTS: Initial State
Power Dissipation (mW)
Frequency (Hz)
0
10
20
30
40
50
60
70
5
10
15
20
25
30
35
40
45
50
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 7

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
100/F @ 30% RTS: Initial State

ACSR

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	10.696	4	3.74
8	21.392	37	7.48
12	32.088	65	11.23
16	42.784	91	14.97
20	53.480	161	18.71

ACSR/TW

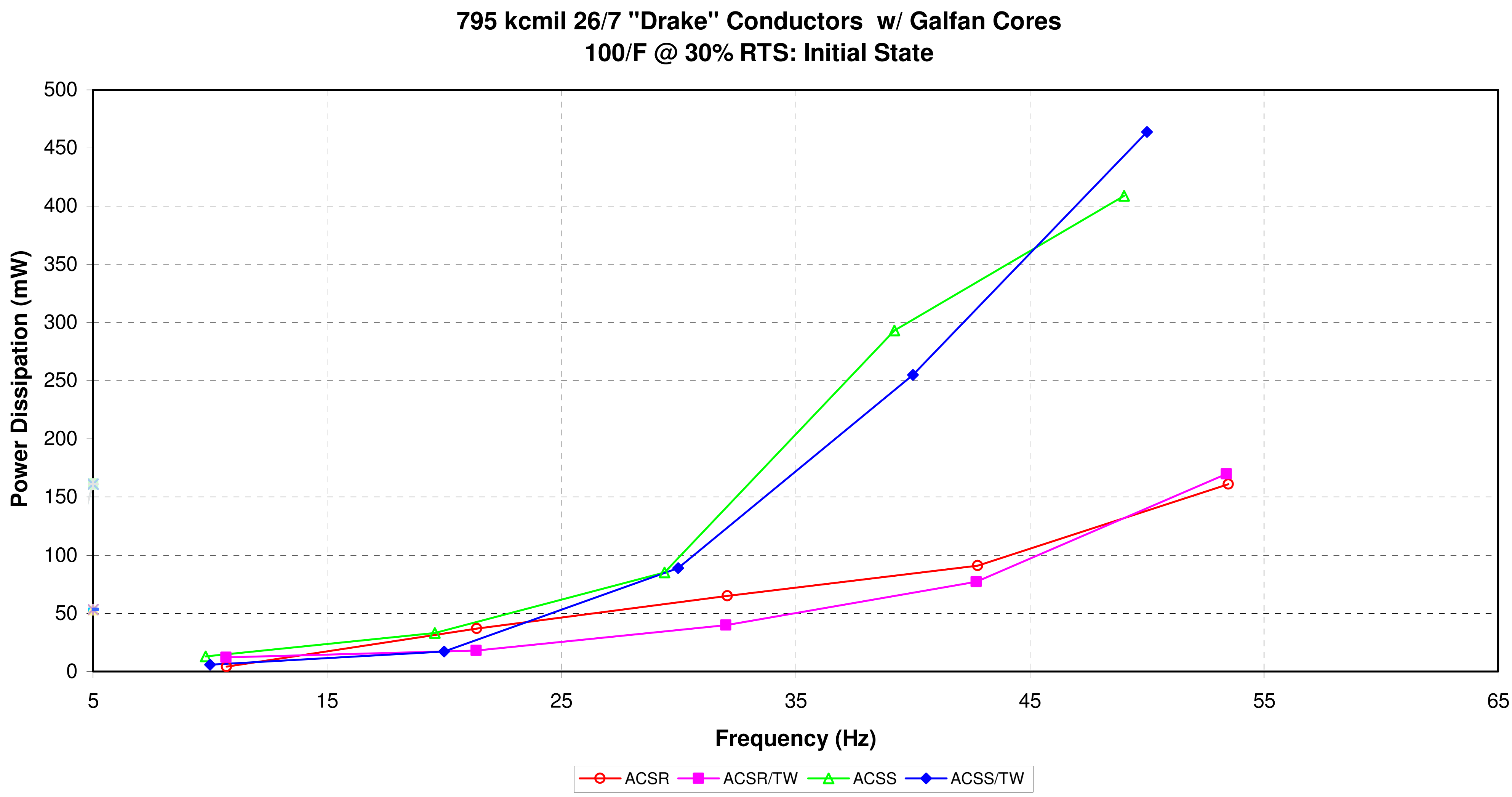
Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	10.680	12	3.41
8	21.360	18	6.81
12	32.040	40	10.22
16	42.720	77	13.62
20	53.400	170	17.03

ACSS

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	9.804	13	3.43
8	19.608	33	6.85
12	29.412	85	10.28
16	39.216	293	13.71
20	49.020	409	17.13

ACSS/TW

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	10.000	6	3.19
8	20.000	17	6.38
12	30.000	89	9.57
16	40.000	255	12.76
20	50.000	464	15.95



795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
100/F @ 30% RTS: Initial State
Power Dissipation (mW)
500
450
400
350
300
250
200
150
100
50
0
5
15
25
35
45
55
65
Frequency (Hz)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 8

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
67/F @ 30% RTS: Initial State

ACSR

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	10.696	14	3.74
8	21.392	25	7.48
12	32.088	34	11.23
16	42.784	45	14.97
20	53.480	88	18.71

ACSR/TW

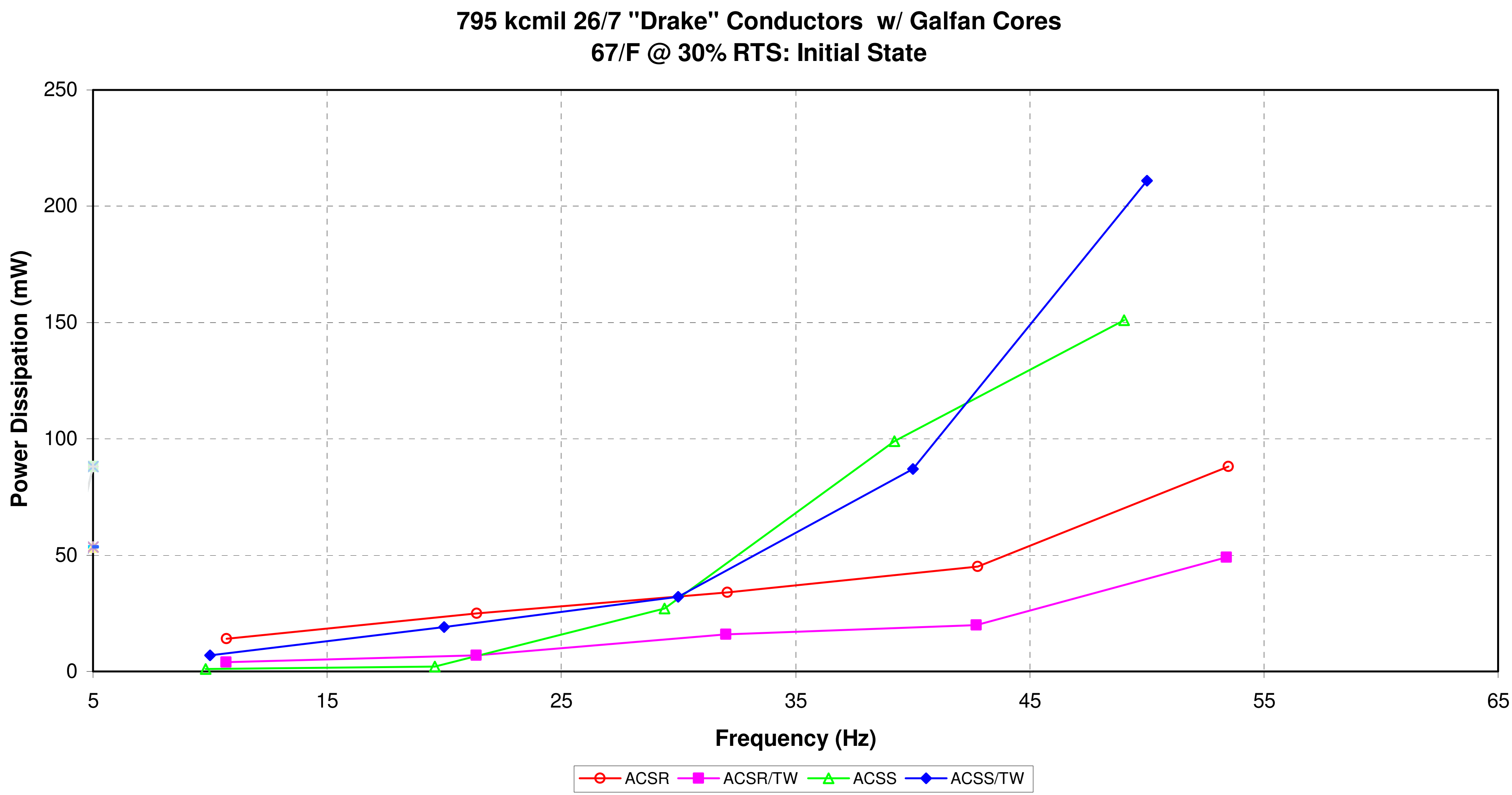
Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	10.680	4	3.41
8	21.360	7	6.81
12	32.040	16	10.22
16	42.720	20	13.62
20	53.400	49	17.03

ACSS

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	9.804	1	3.43
8	19.608	2	6.85
12	29.412	27	10.28
16	39.216	99	13.71
20	49.020	151	17.13

ACSS/TW

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	10.000	7	3.19
8	20.000	19	6.38
12	30.000	32	9.57
16	40.000	87	12.76
20	50.000	211	15.95



795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
67/F @ 30% RTS: Initial State
Power Dissipation (mW)
0
50
100
150
200
250
5
15
25
35
45
55
65
Frequency (Hz)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 9

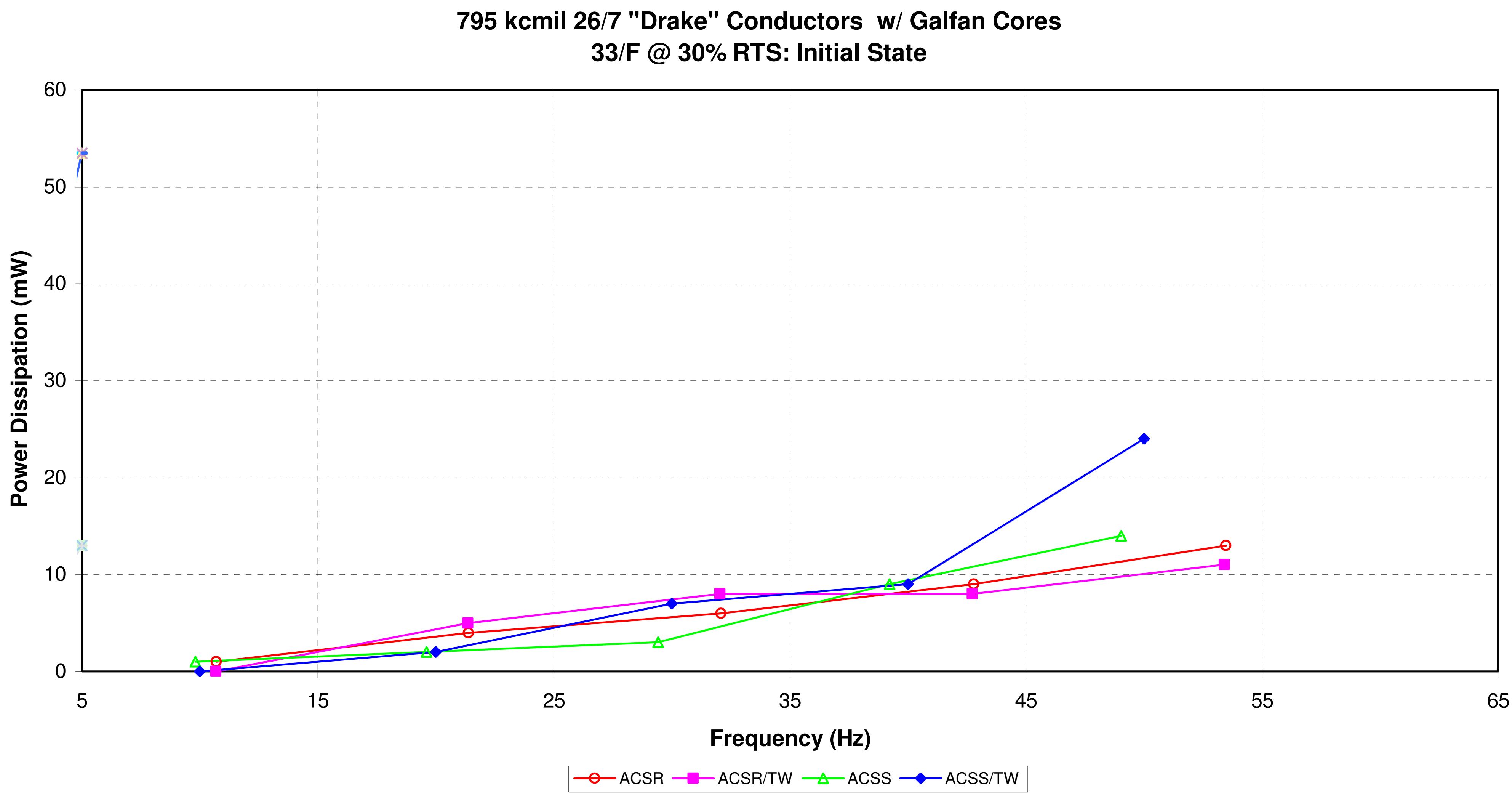
Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
33/F @ 30% RTS: Initial State

ACSR			
Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	10.696	1	3.74
8	21.392	4	7.48
12	32.088	6	11.23
16	42.784	9	14.97
20	53.480	11	18.71

ACSR/TW			
Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	10.680	0	3.41
8	21.360	5	6.81
12	32.040	8	10.22
16	42.720	8	13.62
20	53.400	11	17.03

ACSS			
Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	9.804	1	3.43
8	19.608	2	6.85
12	29.412	3	10.28
16	39.216	9	13.71
20	49.020	14	17.13

ACSS/TW			
Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	10.000	0	3.19
8	20.000	2	6.38
12	30.000	7	9.57
16	40.000	9	12.76
20	50.000	24	15.95



795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
33/F @ 30% RTS: Initial State
Power Dissipation (mW)
0
10
20
30
40
50
60
5
15
25
35
45
55
65
Frequency (Hz)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 10

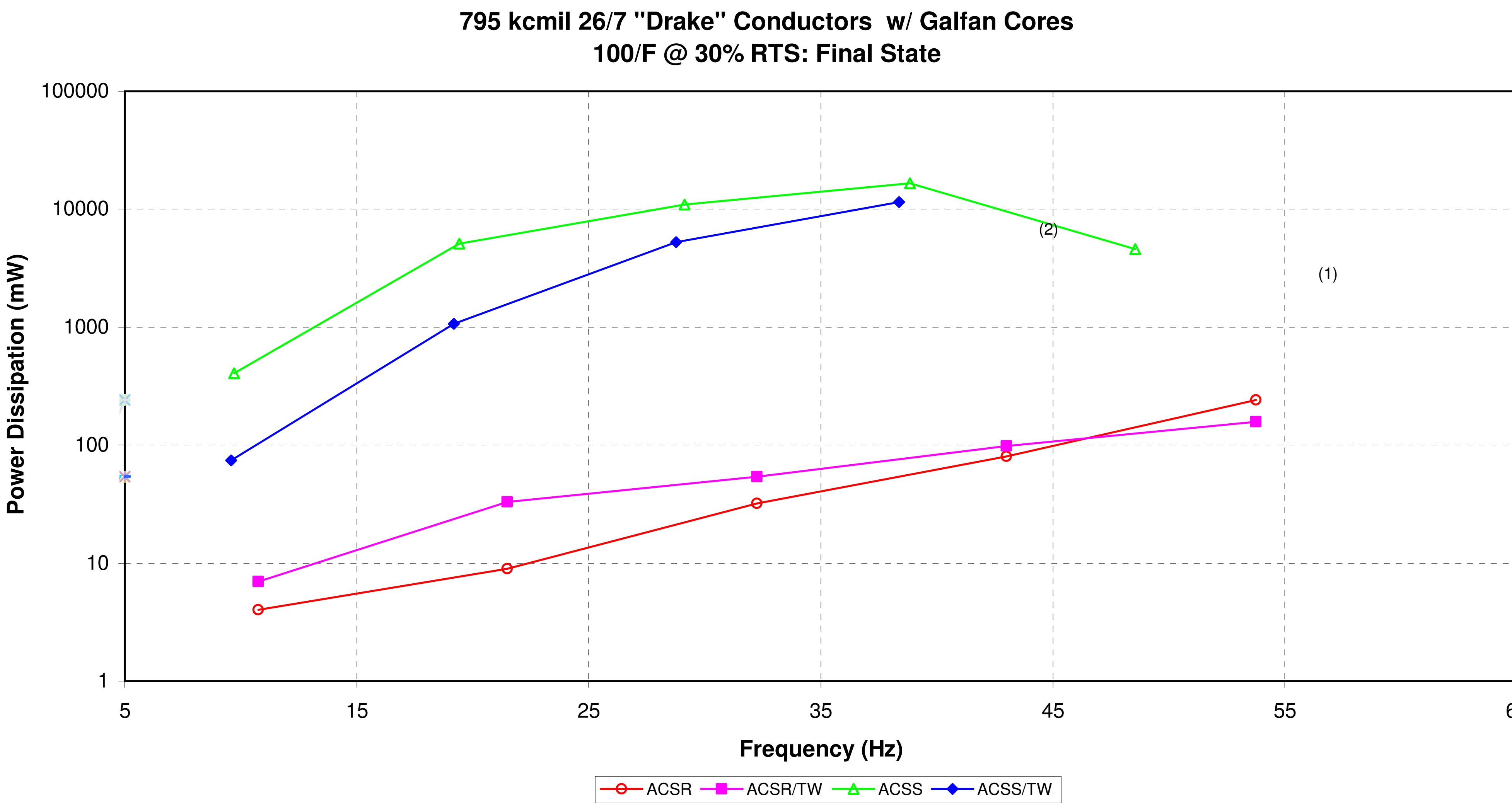
Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
100/F @ 30% RTS: Final State

ACSR			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	10.752	4	3.76
8	21.504	9	7.52
12	32.256	32	11.29
16	43.008	80	15.05
20	53.760	242	18.81

ACSR/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	10.752	7	3.43
8	21.504	33	6.86
12	32.256	54	10.29
16	43.008	98	13.72
20	53.760	158	17.14

ACSS			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	9.708	405	3.39
8	19.416	5113	6.79
12	29.124	10903	10.18
16	38.832	16587	13.57
20	48.540	4581	16.97

ACSS/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	9.592	74	3.06
8	19.184	1070	6.12
12	28.776	5276	9.18
16	38.368	11505	12.24
20	47.960	----	15.30



795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
100/F @ 30% RTS: Final State
Power Dissipation (mW)
100000
10000
1000
100
10
1
5
15
25
35
45
55
65
Frequency (Hz)
(1)
(2)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 11

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
67/F @ 30% RTS: Final State

ACSR			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	10.752	3	3.76
8	21.504	15	7.52
12	32.256	15	11.29
16	43.008	47	15.05
20	53.760	65	18.81

ACSR/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	10.752	1	3.43
8	21.504	15	6.86
12	32.256	24	10.29
16	43.008	40	13.72
20	53.760	56	17.14

ACSS			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	9.708	278	3.39
8	19.416	3402	6.79
12	29.124	7042	10.18
16	38.832	6627	13.57
20	48.540	----	16.97

ACSS/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	9.592	51	3.06
8	19.184	738	6.12
12	28.776	2645	9.18
16	38.368	4866	12.24
20	47.960	----	15.30

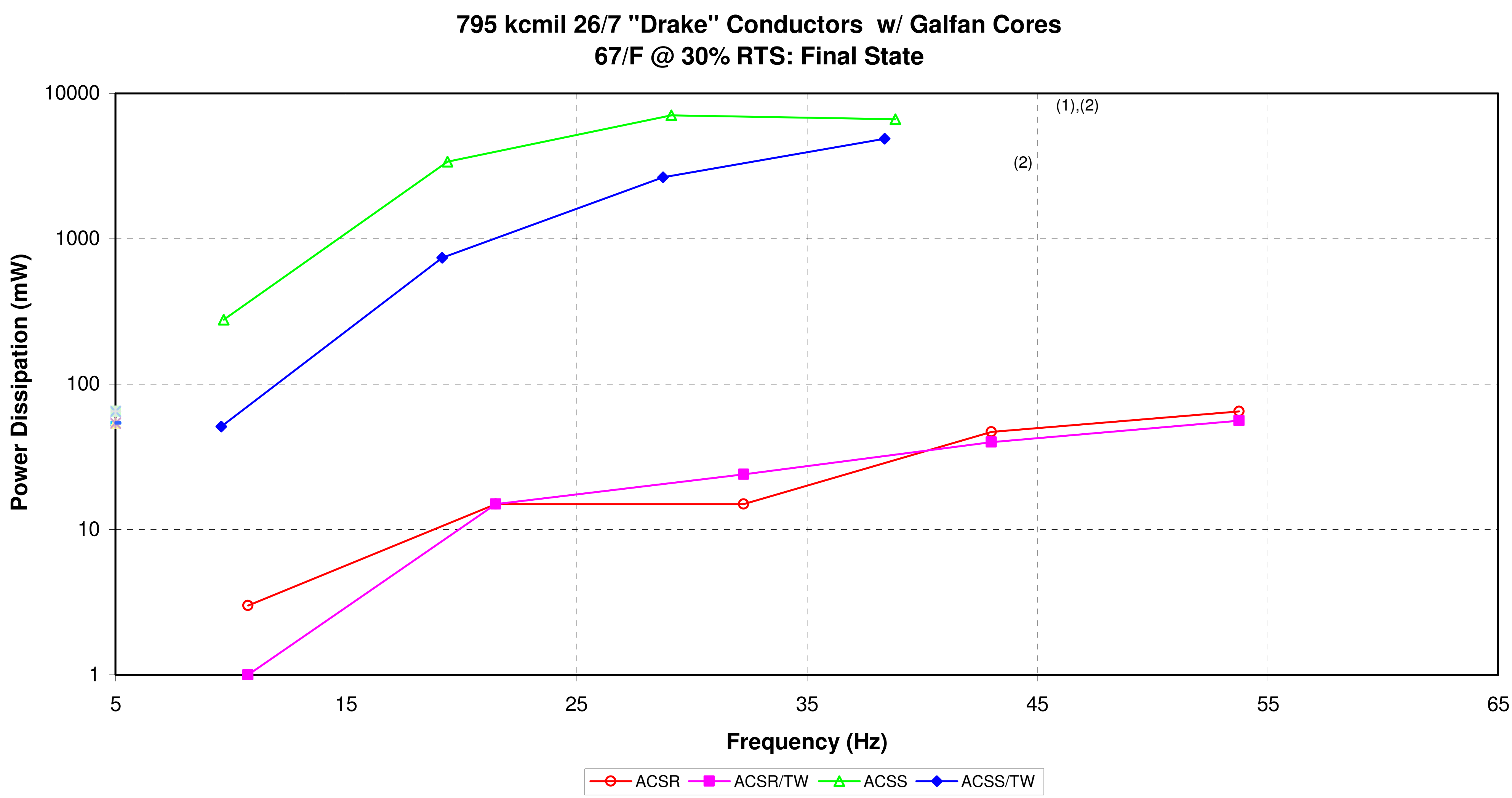

795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
67/F @ 30% RTS: Final State
Power Dissipation (mW)
10000
1000
100
10
1
Frequency (Hz)
5
15
25
35
45
55
65
(1),(2)
(2)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 12

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
33/F @ 30% RTS: Final State

ACSR			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	10.752	3	3.76
8	21.504	6	7.52
12	32.256	6	11.29
16	43.008	8	15.05
20	53.760	20	18.81

ACSR/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	10.752	2	3.43
8	21.504	1	6.86
12	32.256	3	10.29
16	43.008	5	13.72
20	53.760	17	17.14

ACSS			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	9.708	4	3.39
8	19.416	16	6.79
12	29.124	878	10.18
16	38.832	1518	13.57
20	48.540	----	16.97

ACSS/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	9.592	2	3.06
8	19.184	44	6.12
12	28.776	486	9.18
16	38.368	2042	12.24
20	47.960	----	15.30

795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
33/F @ 30% RTS: Final State

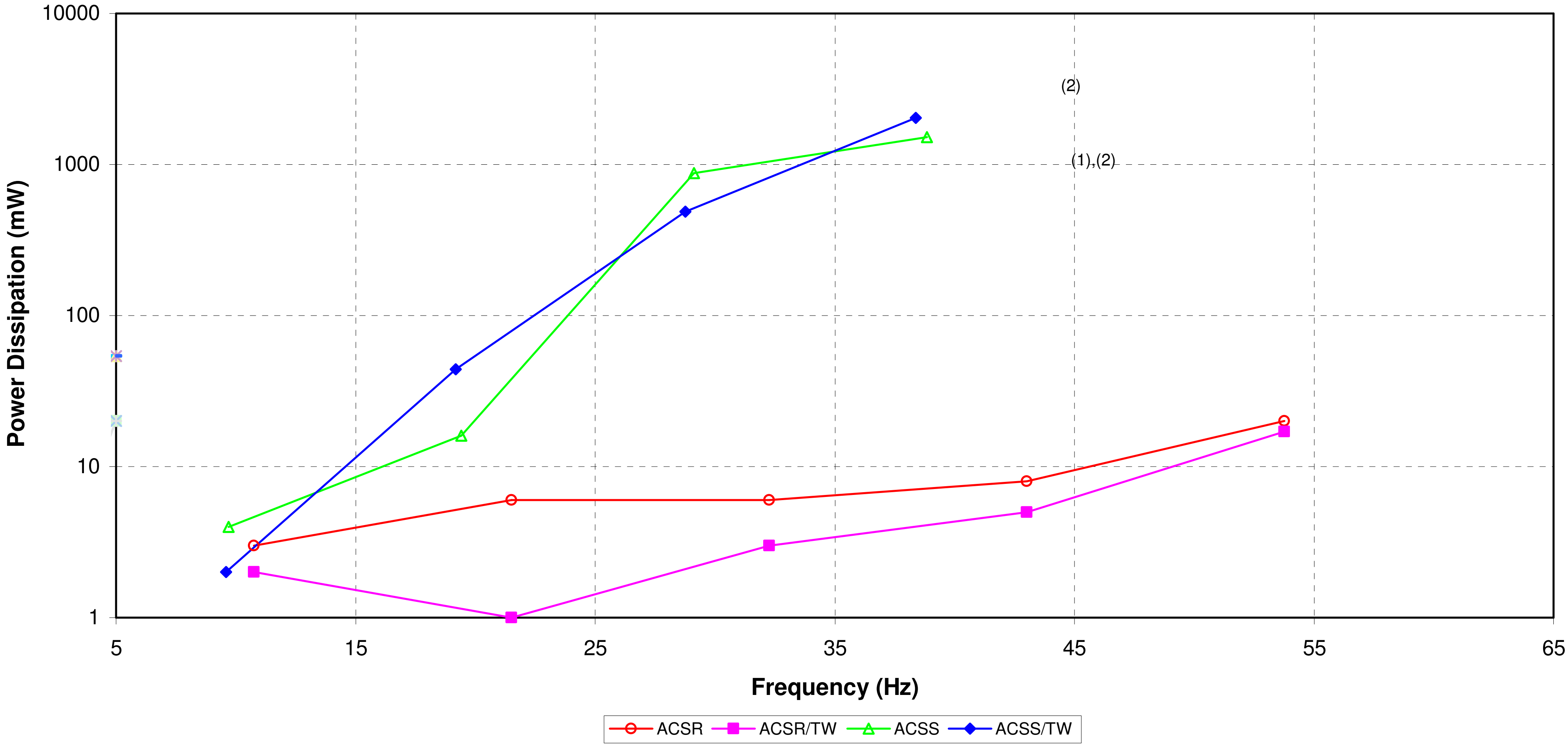


Table 13

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
100/F @ 20% RTS: Final State

ACSR			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	8.940	9	3.13
8	17.880	25	6.26
12	26.820	99	9.38
16	35.760	259	12.51
20	44.700	552	15.64

ACSR/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	8.908	9	2.84
8	17.816	20	5.68
12	26.724	76	8.52
16	35.632	231	11.36
20	44.540	522	14.20

ACSS			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	8.064	245	2.82
8	16.128	2798	5.64
12	24.192	8053	8.46
16	32.256	4243	11.27
20	40.320	3747	14.09

ACSS/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.684	252	2.45
8	15.368	3074	4.90
12	23.052	7681	7.35
16	30.736	10665	9.80
20	38.420	----	12.25

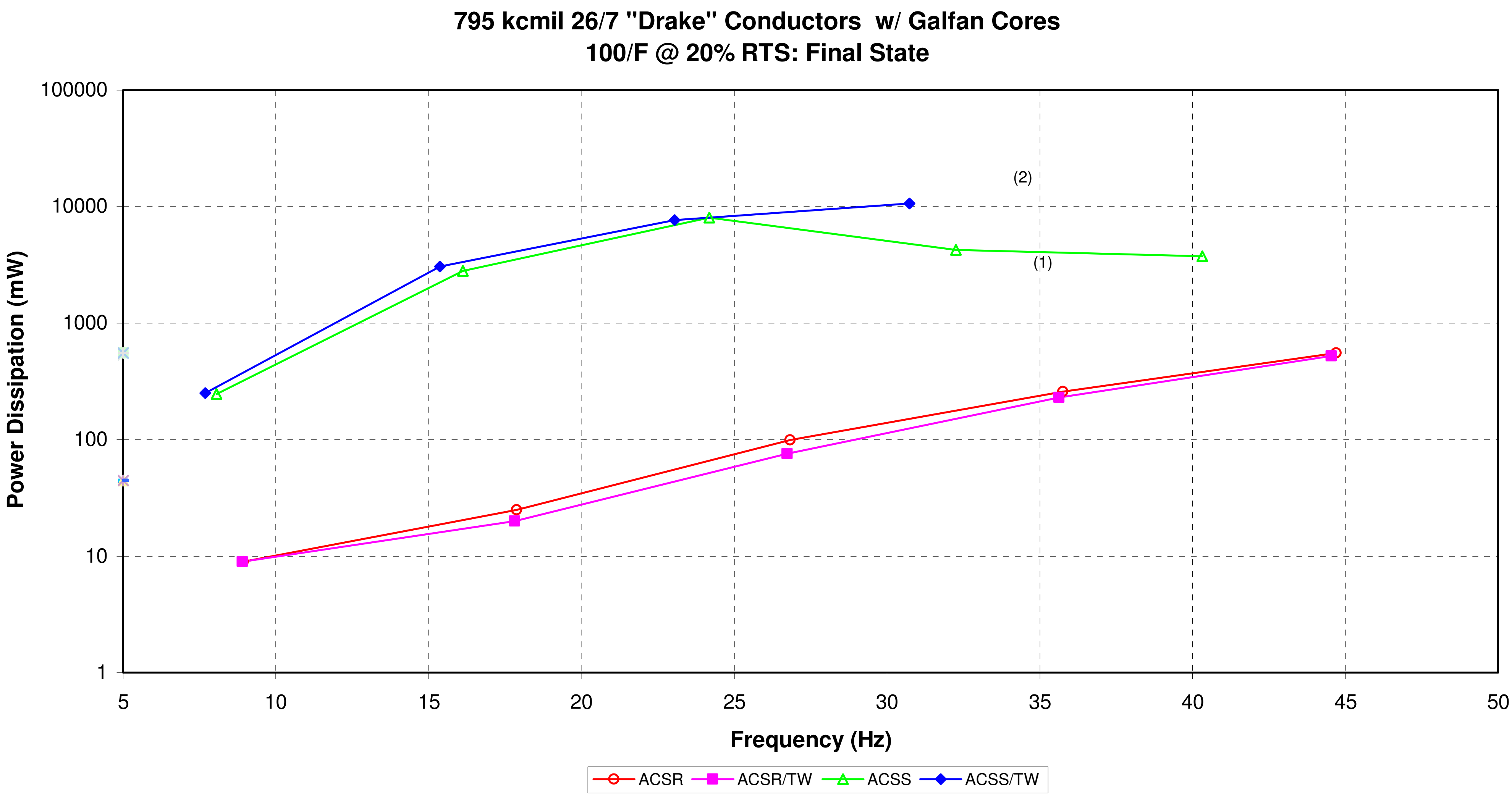

795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
100/F @ 20% RTS: Final State
Power Dissipation (mW)
100000
10000
1000
100
10
1
Frequency (Hz)
5
10
15
20
25
30
35
40
45
50
(2)
(1)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 14

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
67/F @ 20% RTS: Final State

ACSR			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	8.940	2	3.13
8	17.880	11	6.26
12	26.820	47	9.38
16	35.760	95	12.51
20	44.700	157	15.64

ACSR/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	8.908	2	2.84
8	17.816	14	5.68
12	26.724	24	8.52
16	35.632	58	11.36
20	44.540	104	14.20

ACSS			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	8.064	10	2.82
8	16.128	1694	5.64
12	24.192	5177	8.46
16	32.256	3254	11.27
20	40.320	2485	14.09

ACSS/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.684	25	2.45
8	15.368	2148	4.90
12	23.052	4688	7.35
16	30.736	6468	9.80
20	38.420	----	12.25

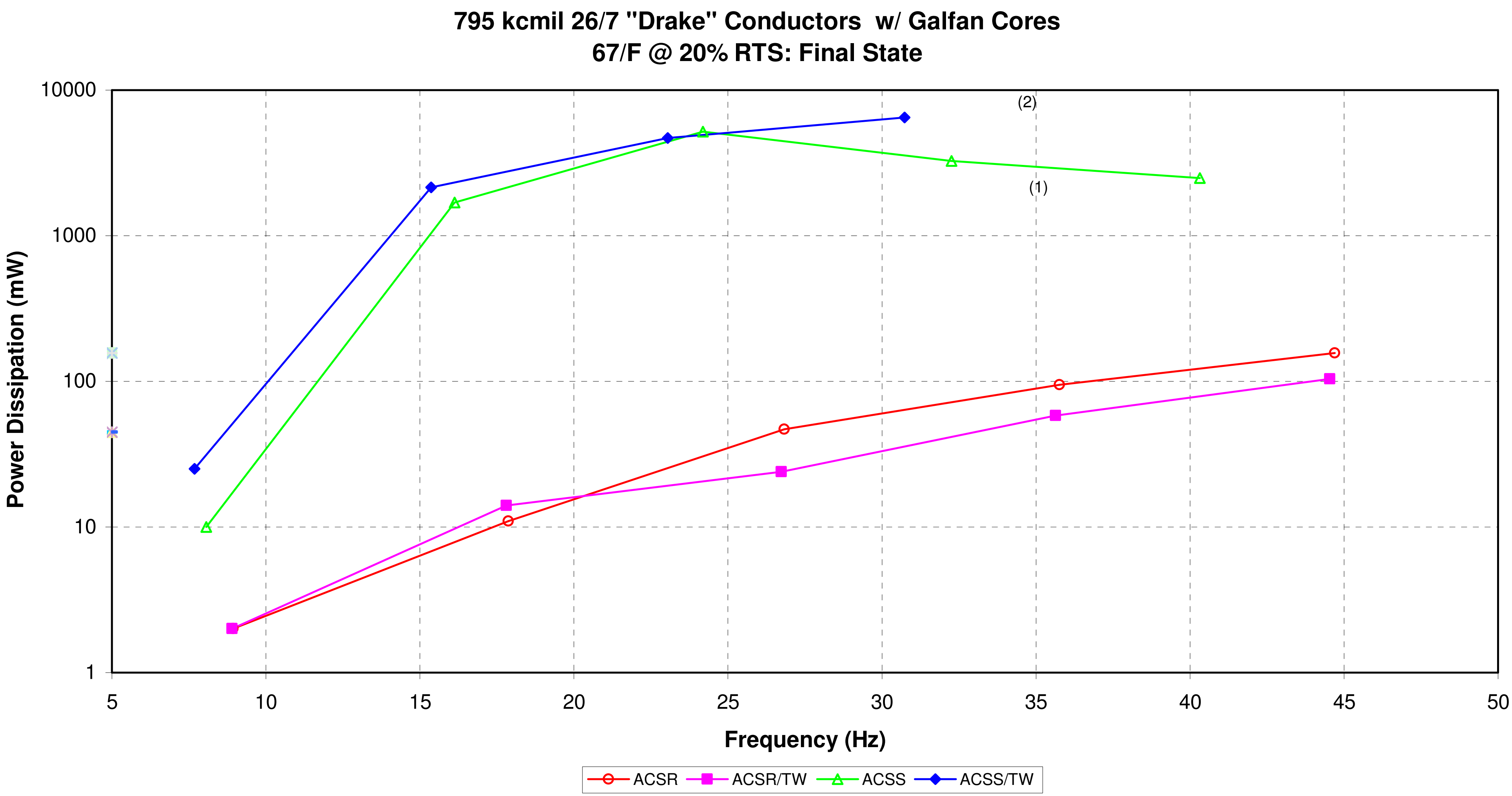

795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
67/F @ 20% RTS: Final State
Power Dissipation (mW)
10000
1000
100
10
1
Frequency (Hz)
5
10
15
20
25
30
35
40
45
50
(2)
(1)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 15

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
33/F @ 20% RTS: Final State

ACSR

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	8.940	1	3.13
8	17.880	2	6.26
12	26.820	4	9.38
16	35.760	7	12.51
20	44.700	20	15.64

ACSR/TW

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	8.908	1	2.84
8	17.816	1	5.68
12	26.724	6	8.52
16	35.632	10	11.36
20	44.540	15	14.20

ACSS

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	8.064	5	2.82
8	16.128	20	5.64
12	24.192	692	8.46
16	32.256	1024	11.27
20	40.320	929	14.09

ACSS/TW

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	7.684	11	2.45
8	15.368	31	4.90
12	23.052	181	7.35
16	30.736	1091	9.80
20	38.420	----	12.25

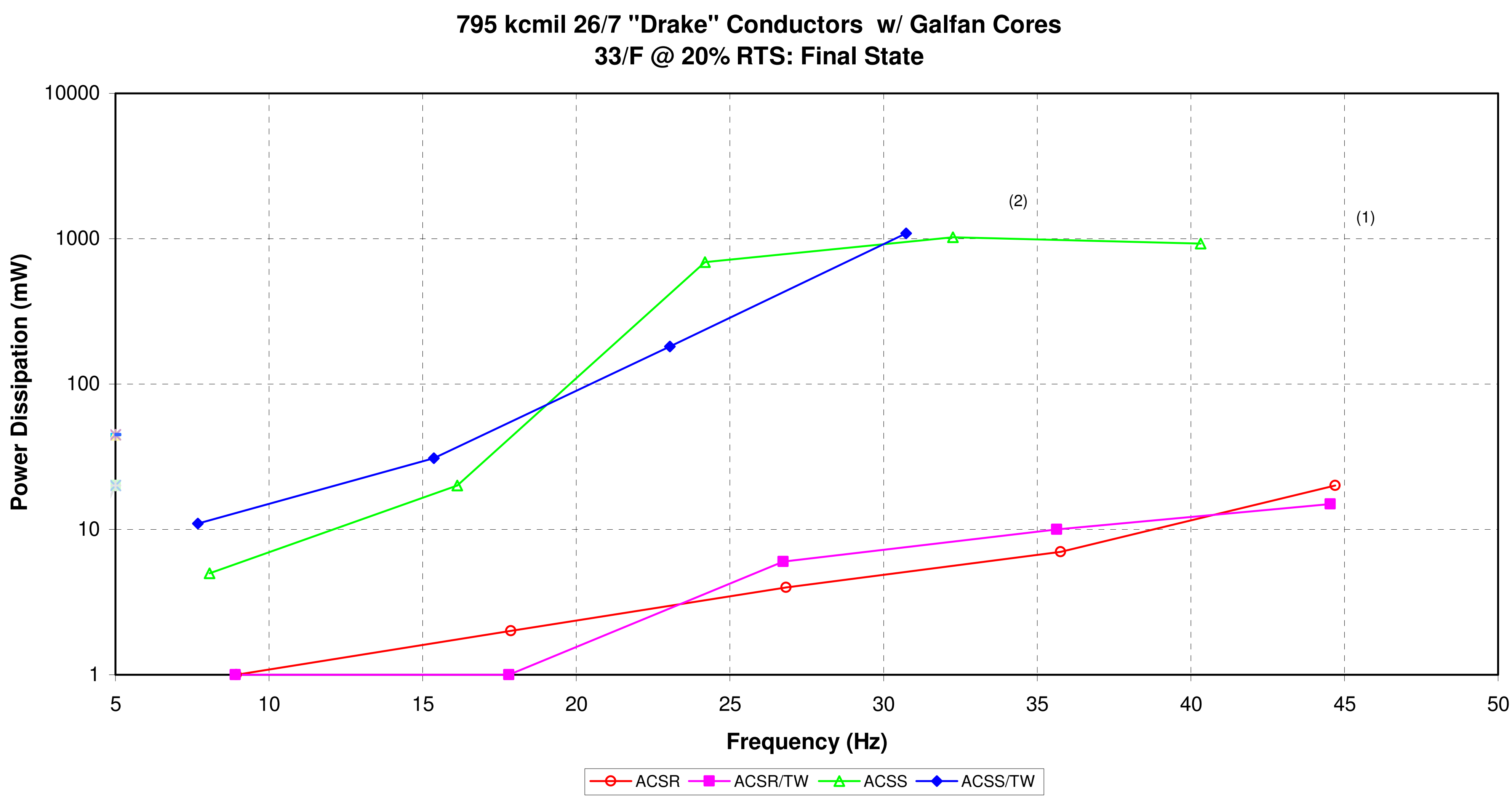

795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
33/F @ 20% RTS: Final State
Power Dissipation (mW)
10000
1000
100
10
1
Frequency (Hz)
5
10
15
20
25
30
35
40
45
50
(2)
(1)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 16

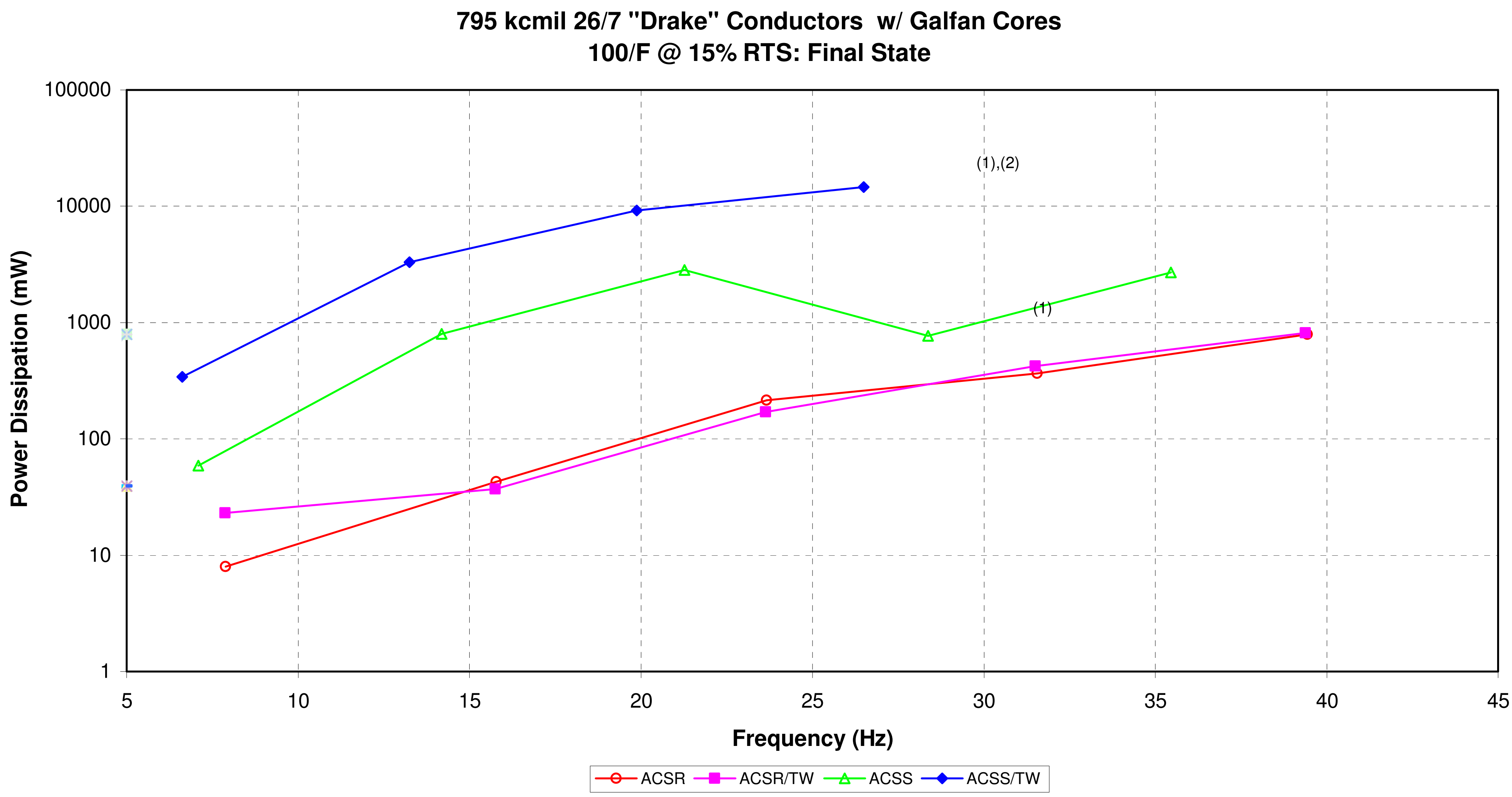
Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
100/F @ 15% RTS: Final State

ACSR			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.888	8	2.76
8	15.776	43	5.52
12	23.664	214	8.28
16	31.552	366	11.04
20	39.440	788	13.80

ACSR/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.876	23	2.51
8	15.752	37	5.02
12	23.628	170	7.54
16	31.504	423	10.05
20	39.380	811	12.56

ACSS			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	7.092	59	2.48
8	14.184	796	4.96
12	21.276	2834	7.44
16	28.368	771	9.92
20	35.460	2706	12.39

ACSS/TW			
Mode (loops)	**Frequency (Hz)**	**Power (milliwatts)**	**Wind (mph)**
4	6.624	341	2.11
8	13.248	3298	4.22
12	19.872	9237	6.34
16	26.496	14615	8.45
20	33.120	----	10.56



795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
100/F @ 15% RTS: Final State
Power Dissipation (mW)
100000
10000
1000
100
10
1
5
10
15
20
25
30
35
40
45
Frequency (Hz)
(1),(2)
(1)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 17

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
67/F @ 15% RTS: Final State

ACSR

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	7.888	5	2.76
8	15.776	16	5.52
12	23.664	62	8.28
16	31.552	128	11.04
20	39.440	267	13.80

ACSR/TW

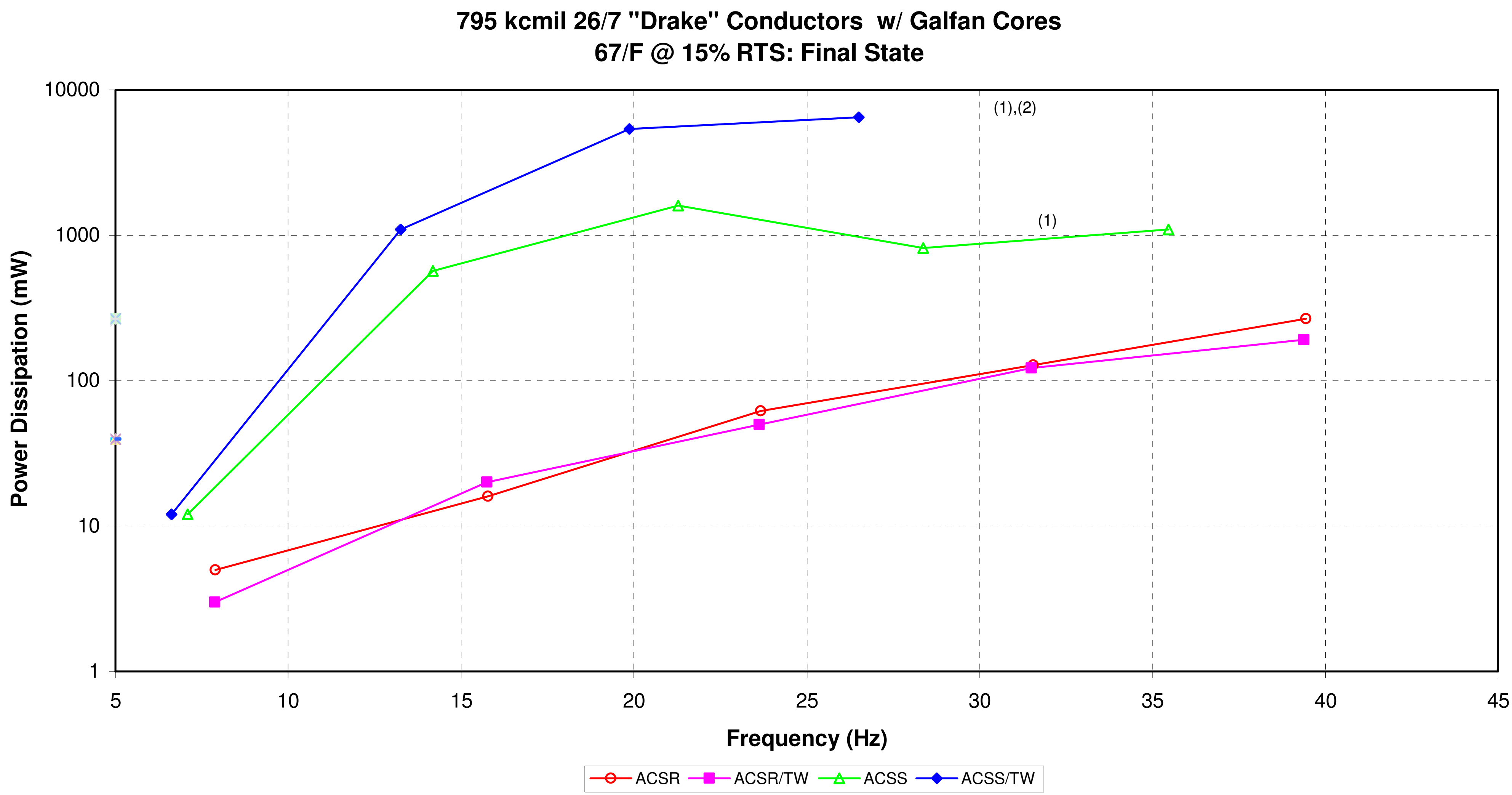
Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	7.876	3	2.51
8	15.752	20	5.02
12	23.628	50	7.54
16	31.504	122	10.05
20	39.380	192	12.56

ACSS

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	7.092	12	2.48
8	14.184	571	4.96
12	21.276	1601	7.44
16	28.368	819	9.92
20	35.460	1095	12.39

ACSS/TW

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	6.624	12	2.11
8	13.248	1097	4.22
12	19.872	5386	6.34
16	26.496	6505	8.45
20	33.120	----	10.56



795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
67/F @ 15% RTS: Final State
Power Dissipation (mW)
10000
1000
100
10
1
Frequency (Hz)
5
10
15
20
25
30
35
40
45
(1),(2)
(1)
ACSR
ACSR/TW
ACSS
ACSS/TW

Table 18

Free Span Self-Damping Results for 795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
33/F @ 15% RTS: Final State

ACSR

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	7.888	1	2.76
8	15.776	4	5.52
12	23.664	9	8.28
16	31.552	12	11.04
20	39.440	35	13.80

ACSR/TW

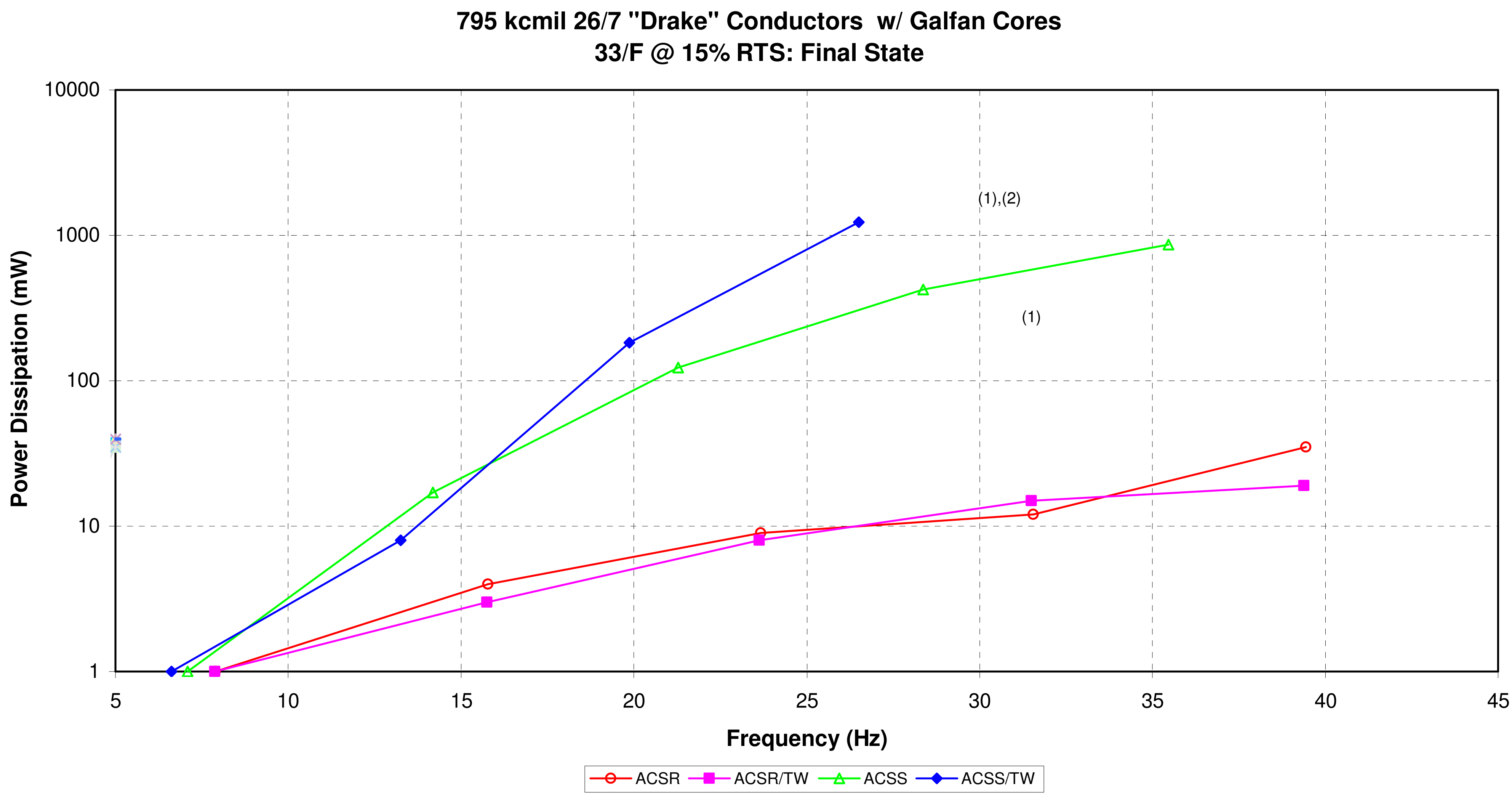
Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	7.876	1	2.51
8	15.752	3	5.02
12	23.628	8	7.54
16	31.504	15	10.05
20	39.380	19	12.56

ACSS

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	7.092	1	2.48
8	14.184	17	4.96
12	21.276	123	7.44
16	28.368	425	9.92
20	35.460	862	12.39

ACSS/TW

Mode (loops)	Frequency (Hz)	Power (milliwatts)	Wind (mph)
4	6.624	1	2.11
8	13.248	8	4.22
12	19.872	183	6.34
16	26.496	1233	8.45
20	33.120	----	10.56


795 kcmil 26/7 "Drake" Conductors w/ Galfan Cores
33/F @ 15% RTS: Final State
Power Dissipation (mW)
10000
1000
100
10
1
5
10
15
20
25
30
35
40
45
Frequency (Hz)
(1),(2)
(1)
ACSR
ACSR/TW
ACSS
ACSS/TW