



# Academy of Model Aeronautics

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## RULES CHANGE PROPOSAL FORM

Click **SUBMIT** button to send to AMA Headquarters

**A copy will be forwarded to the appropriate Contest Board Chairman. The current issue of Competition Regulations must be referenced.**

PROPOSAL NO. CLSC15-4CP2

(To be inserted by Headquarters)

RECEIVED DATE 6/30/2014

(To be inserted by Headquarters)

REVISE DATE \_\_\_\_\_

VERSION NUMBER \_\_\_\_\_

PROPOSAL TYPE (Check One):  Basic  Urgent  Safety/Emergency  Interpretation

X Cross (Indicate Original Proposal Number) CLSC15-4

- General Section  Executive Council  Outdoor Free Flight  Indoor Free Flight  CL Speed  
 CL Racing  CL Navy Carrier  CL Aerobatics  CL Combat  CL Special Events  RC Aerobatics  
 RC Scale Aerobatics  RC Pylon Racing  RC Helicopter  RC Soaring X CL Scale  FF Scale  
 RC Scale  Electric  Special Events  RC Combat

**Brief summary of the proposed change.**

Cross Proposal to CLSC 15-4 to Correct Line-Pull Test Chart

**Exact wording proposed for the rule book. (List paragraph numbers where applicable. Example: Change “quote present rule book wording” to “exact wording required”.**

**NOTE: This cross proposal will not be brief. The following 8 page Technical Report has the series of assumptions, tradeoffs and calculations that Kent Walters has requested.**

## **Technical Report: Determining CL Scale Line Sizes and Pull Tests Required Based on Line Load Safety Calculations**

Thanks for all your inputs. As a result I have redone all the calculations to address you inputs and issues raised by Kent Walters of the AMA Scale Contest Board.

**Assumption: Dacron is an approximately 0.014 inch diameter string with a breaking strength of approximately the same as 0.008 inch wire rope.**

### **Primary issues:**

**A. Pull Test with safety factor that more than the maximum amount of pull on lines in the Worst Case Flight for each model weight category.**

**B. Line Strength using industry data and safety factors from the AMA rule set that specifies the diameter that can withstand the expected maximum amount of pull on lines in the Worst Case Flight for each model weight category.**

## Worst Case Flight:

The determination of the worst case flight is dependent on the physical aspects of the models and its control system, and the maximum speed the model is flown.

**Physical Aspects:** The contestant builds a model that has a specific dry mass weight. The model mass weight puts the model into one of the seven (7) weight bracket categories. The model mass weight bracket category is used to specify the range of line lengths (max-min --- model centerline to handle grip) and the minimum line diameter for the line type (wire rope or music wire) and their number of load bearing lines. All of these data are acquired during the model processing and in the pull test area during the flying portion of the contest.

**Maximum Velocity flown:** This challenge had to be addressed when the issue of the 60 mph speed limit was challenged as being impractical to manage at a contest and to limiting to requirements of the scale builder-flyer. This means an assumption must be made for the maximum expected speed in each of the seven (7) line categories determined by maximum model weight.

The following chart displays maximum speed assumptions that are expected for the different maximum weight models in each class:

1st Pass Estimate	
Max Model Weight	Max Speed
Pounds	MPH
0.75	60
1.5	70
2.5	80
4	85
8	70
12	65
20	60

These assumed maximum speeds fall below other CL events of speed, racing, combat and navy carrier. But they are equal to or higher than

the prior sixty (60) mph limit. The logic behind the assumption process included the ability of the pilot to control the heavier models at higher speed and flight experience of expert control line scale modelers.

### Calculation of Line Loads During Flight:

Using the standard AMA line load equation for the Worst Case Flight:

$$L = N * M * V * V / R$$

N = .0673 a constant

M = mass weight of model in pounds

V = velocity in miles per hour

R = radius from handle to centerline of model.

The required AMA safety factors are:

1.2 for wind times 1.1 for safety

The results for our wire line size categories are:

Centrifugal Force*1.2 Factor for Wind * 1.1 Safety Factor					
Max Model Weight	Minimum Lines-Ft Length	Max Velocity mph	Max G Load	Max Line (s) Load	Max Pilot Sec/Rev
0.75	25	60	12.79	9.59	1.78
1.5	35	70	12.44	18.66	2.14
2.5	52.5	80	10.83	27.07	2.81
4	52.5	85	12.27	49.07	2.65
8	52.5	75	9.56	76.48	3.00
12	65	65	5.81	69.70	4.28
20	65	60	4.92	98.40	4.64

Max Load with Safety Factors			
Max Model Weight	Max G Load	Max Line (s) Load	Current Pull Test G's
Pounds	Load	Load	G's
0.75	12.79	9.59	10
1.5	12.44	18.66	10
2.5	10.83	27.07	5
4	12.27	49.07	5
8	9.56	76.48	5
12	5.81	69.70	5
20	4.92	98.40	5

We can observe the Worst Case Flight line load in each model weight category. The Maximum G loads are mostly higher than the pull test G load. Some have more than twice the Max G Load then the Current Pull Test.

CL Scale uses two types of steel lines: Wire Rope and Music Wire.

## Line Strength – Wire Rope

Wire Rope		Single Lines			Strength
Swaged Eye Factor		90%			Used In
ASTMA Data			Manf Test Data		
305 and 316 Stainless					Analysis
	Wire	Swaged	Manf Test	Swaged	Lowest
Line Size	Max Load	Max Load	Max Load	Max Load	of 2 Tables
Inches	Pounds	Pounds	Pounds	Pounds	Pounds
0.008			10	9.00	9.00
0.010	Extrapolated by cross-section area.				13.63
0.012	21.11	19.00	20	18.00	19.00
0.014	28.74	25.87			25.87
0.015	32.99	29.69	30	27.00	29.69
0.018	47.50	42.75	45	40.50	40.50
0.021	64.65	58.19	60	54.00	54.00
0.024			90	81.00	81.00
0.027			135	121.50	121.50

Required Single Line Strength Wire Rope (Stranded)				
Wire	Single Line	Safety Factors For # of Lines		
Size	Breaking	1 Line	2 Lines	3 Lines
Inches	Strength	56%	86%	116%
0.008	9.00	5.04	7.74	10.44
0.010	13.63	7.63	11.72	15.81
0.012	19.00	10.64	16.34	22.04
0.014	25.87	14.48	22.24	30.00
0.015	29.69	16.63	25.53	34.44
0.018	40.50	22.68	34.83	46.98
0.021	54.00	30.24	46.44	62.64
0.024	81.00	45.36	69.66	93.96
0.027	121.50	68.04	104.49	140.94

The factors of **56%** for one (1) and **86%** two (2) lines are AMA factors and **116%** is an extrapolation to three (3) lines.

Reviewing the last two columns we see that the Wire Rope lines load carrying capacity is in most cases within about 90% of the Worse Case flight line load. Based

Max Loads Applied to Line Sizes for 2015-2016 AMA Rule Set								
Model	Line Size		Maximum Carry Load		Max	Wire Rope (Stranded)		
Weight			Based on Line Size		Load	Percent of Safe Load		
Pounds	2 Lines	3 Lines	2 Lines	3 Lines	Expected	2 Lines	3 Lines	
.0 --.75	0.01	0.008	11.72	10.44	9.59	122.2%	108.9%	
.75 – 1.50	0.012	0.01	16.34	15.81	18.66	87.6%	84.7%	
1.51 – 2.50	0.015	0.014	22.24	30.00	27.07	82.2%	110.8%	
2.51 – 4	0.021	0.018	46.44	46.98	49.07	94.6%	95.7%	
4.01 – 8	0.024	0.021	69.66	62.64	76.48	91.1%	81.9%	
8.01 – 12	0.024	0.021	69.66	62.64	69.70	99.9%	89.9%	
12.01 – 20	0.027	0.024	104.49	93.96	98.40	106.2%	95.5%	

on the limitations of our assumptions this is within a safe range.

# Line Strength – Music Wire

## AMA Competition Regulations 2013-2014 Control Line General page CLG-2

### Single Wire ASME Steel

Line	Size	Inches	0.008	0.01	0.012	0.014	0.016	0.018	0.022	0.026
Minimum	Breaking	Pounds	17.6	22.3	27.4	52.8	68.3	85.6	125.3	172.1

Music Wire		Single Lines		Strength
				Used In
ASME				Analysis
		0.9		
	Wire		Swaged	
Line Size	Max Load		Max Load	Max Load
Inches	Pounds		Pounds	Pounds
0.008	17.60		15.84	15.84
0.010	22.30		20.07	20.07
0.012	27.40		24.66	24.66
0.014	52.80		47.52	47.52
0.160	68.30		61.47	61.47
0.018	85.60		77.04	77.04
0.020			94.91	94.91
0.022	125.30		112.77	112.77
0.024			133.83	133.83
0.026	172.10		154.89	154.89

Required Single Line Strength Music Wire (Solids)				
Wire	Single Line	Factors For # of Lines		
Size	Breaking	1 Line	2 Lines	3 Lines
Inches	Strength	56%	86%	116%
0.008	15.84	8.87	13.62	18.37
0.010	20.07	11.24	17.26	23.28
0.012	24.66	13.81	21.21	28.61
0.014	47.52	26.61	40.87	55.12
0.016	61.47	34.42	52.86	71.31
0.018	77.04	43.14	66.25	89.37
0.020	94.91	53.15	81.62	110.09
0.022	112.77	63.15	96.98	130.81
0.024	133.83	74.94	115.09	155.24
0.026	154.89	86.74	133.21	179.67

Max Loads Applied to Line Sizes for 2015-2016 AMA Rule Set										
	Line Size			Maximum Carry Load			Max	Music Wire (Solids)		
Weight				Based on Line Size			Load	Percent of Safe Load		
Pounds	1 Line	2 Lines	3 Lines	1 Line	2 Lines	3 Lines	Expected	1 Line	2 Lines	3 Lines
.0 --.75	0.01	0.008	0.008	11.24	13.62	18.37	9.59	117.2%	142.0%	191.6%
.75 – 1.50	0.014	0.01	0.008	26.61	17.26	18.37	18.66	142.6%	92.5%	98.5%
1.51 – 2.50	0.014	0.012	0.01	26.61	21.21	23.28	27.07	98.3%	78.3%	86.0%
2.51 – 4	0.018	0.014	0.014	43.14	40.87	55.12	49.07	87.9%	83.3%	112.3%
4.01 – 8	0.024	0.018	0.016	74.94	66.25	71.31	76.48	98.0%	86.6%	93.2%
8.01 – 12	0.022	0.018	0.016	63.15	66.25	71.31	69.70	90.6%	95.1%	102.3%
12.01 – 20	0.026	0.022	0.018	86.74	96.98	89.37	98.40	88.1%	98.6%	90.8%

The Wire Cable and Music Wire sizes selected seem to have adequate load carrying capability and are mostly at 90% or above of the needed safety line.

Remaining issue to be worked is:

### A. Assuring Max Expected Flight Loads are less than Pull Test

The following are proposed model weight/line data charts

#### Dacron Lines

Model	Required	CL Flying Scale					
Weight	Model Centerline to	Single Strand			Multi-Strand		Pull
Pounds	Handle Grip Length	1 Line	2 Lines	3 Lines	2 Lines	3 Lines	Test
.0 – .5	25' – 45'				.014"	.014"	10G

ASTM A228M music wire and ASTM A 492-95 Wire Rope 305, 316 Stainless



Model	Required	CL Flying Scale					
Weight	Model Centerline to	Single Strand			Multi-Strand		Pull
Pounds	Handle Grip Length	1 Line	2 Lines	3 Lines	2 Lines	3 Lines	Test
.0 – .75	35' – 52.5'	.010"	.008"	.008"	.010"	.008"	10G
.75 – 1.50	35' – 70'	.014"	.010"	.008"	.012"	.010"	10G
1.51 – 2.50	52.5' – 70'	.014"	.012"	.010"	.015"	.015"	10G
2.51 – 4	52.5' – 70'	.018"	.014"	.014"	.021"	.018"	10G
4.01 – 8	52.5' – 70'	.024"	.018"	.016"	.024"	.021"	5G
8.01 – 12	65' – 70'	.022"	.018"	.016"	.024"	.021"	5G
12.01 – 20	65' – 70'	.026"	.022"	.018"	.027"	.024"	5G

**Brief summary of the cross proposal.**

The following Kent Walters request resulted in a complete review of the calculations and resulted in making corrections to table , “Also in what you identify as 4.7.2, how is the "expected maximum flight velocity" now determined for wire gauge size and centrifugal force calculations? There is no maximum speed limit of 60 mph now included in these new proposed rules as otherwise published earlier. I thought there was going to be a further analysis a few years ago on what the actual speeds were in CL Scale completion when there was earlier question on the 60 mph along with discussions on control line wire gauge sizes. That study notwithstanding, I notice the wire gauge sizes were generally increased in size in this latest new proposal. As a result, it would appear something was determined to now increase those CL wire sizes. If so, what is the new higher velocity those wire gauge sizes have been selected for? I think that is still important to list as a reference for any models flying faster such as any of the new jets.”

Thank you Kent for addressing this issue. The Technical Report above and following cross proposal makes the corrections.

As reference I have attached a seventeen (17) page technical document that has the detailed rationale for maximum model speed at each weight category and technical references, assumptions, and calculations that were used to arrive at the proposed line diameters. These calculations were made for each of the maximum model weight-minimum line length categories for the number of load bearing lines for the two types of wire: single strand and multi-strand.

**Exact wording for cross proposed.**

**4.7.2.** The line sizes, line lengths, and pull test are designed based on engineering analysis using ASME and other single and multi-strand wire line strength standards, of effects of maximum model weight, expected maximum flight velocity, ~~limitations of pilot capability to withstand line pull,~~ wind on downwind side of the circle, ~~a safety factor of 1.1,~~ line distance from handle to model centerline, ~~limitations of pilot capability to withstand line pull and rotational speed. ,and a safety factor of 1.1.~~ The following table includes maximum flight speed assumed for each model weight category.

**Table: Model Weight Category Maximum Flight Speed Expected**

<b>Centrifugal Force 1.2 Factor for Wind + 1.1 Safety Factor</b>					
<b>Max A/C</b>	<b>Minimum</b>	<b>Max</b>	<b>Max</b>	<b>Max</b>	<b>Max</b>
<b>Weight</b>	<b>Lines-Ft</b>	<b>Velocity</b>	<b>Pull</b>	<b>Line(s)</b>	<b>Pilot</b>
<b>Lb.-mass</b>	<b>Length</b>	<b>MPH</b>	<b>Pounds</b>	<b>Load</b>	<b>Sec/Rev</b>
<b>1.5</b>	<b>35</b>	<b>80</b>	<b>2.9</b>	<b>24.38</b>	<b>1.9</b>
<b>2.5</b>	<b>52.5</b>	<b>90</b>	<b>2.7</b>	<b>34.28</b>	<b>2.5</b>
<b>4</b>	<b>52.5</b>	<b>95</b>	<b>6.2</b>	<b>49.50</b>	<b>2.4</b>
<b>8</b>	<b>52.5</b>	<b>85</b>		<b>73.64</b>	<b>2.6</b>
<b>12</b>	<b>65</b>	<b>75</b>	<b>32.16</b>	<b>86.09</b>	<b>3.7</b>
<b>20</b>	<b>65</b>	<b>65</b>	<b>67.00</b>	<b>107.93</b>	<b>4.3</b>

Centrifugal Force*1.2 Factor for Wind * 1.1 Safety Factor					
Max Model Weight	Minimum Lines-Ft	Max Velocity	Max G	Max Line (s)	Max Pilot
lb-mass	Length	mph	Load	Load	Sec/Rev
0.75	25	60	12.79	9.59	1.78
1.5	35	70	12.44	18.66	2.14
2.5	52.5	80	10.83	27.07	2.81
4	52.5	85	12.27	49.07	2.65
8	52.5	75	9.56	76.48	3.00
12	65	65	5.81	69.70	4.28
20	65	60	4.92	98.40	4.64

**4.7.3. Control Line(s).** The length of the control line(s) measured from the center point of the grip part of the control handle (device) to the fore and aft center line of the model shall be as specified in the CL Scale line size **and for the following** pull test table.

**CL Scale Flying Table:**

**Table: Model Weight Category Line Length and Size, and Pull Test Requirements**

Model Weight	Required Model Centerline to Handle Grip Length	CL Flying Scale					Pull Test
		Single Strand			Multi-Strand		
Pounds		1-Line	2-Lines	3-Lines	2-Lines	3-Lines	
0-1.50	<del>35'/52.5'-70'*</del>	.014"	.014"	.010"	.015"	.012"	10G
1.51-2.50	<del>52.5'-70'</del>	.016"	.014"	.014"	.018"	.015"	5G
2.51-4	<del>52.5'-70'</del>	.020"	.016"	.014"	.021"	.018"	5G
4.01-8	<del>52.5'-70'</del>	.024"	.020"	.016"	.024"	.021"	5G
8.01-12	<del>65'-70'</del>	.026"	.022"	.016"	.027"	.024"	5G
12.01-20	<del>65'-70'</del>	.026"	.024"	.020"	.027"	.024"	5G

## Dacron Lines

Model	Required	CL Flying Scale					
Weight	Model Centerline to	Single Strand			Multi-Strand		Pull
Pounds	Handle Grip Length	1 Line	2 Lines	3 Lines	2 Lines	3 Lines	Test
.0 – .5	25' – 45'				.014"	.014"	10G

## ASTM A228M music wire and ASTM A 492-95 Wire Rope 305, 316 Stainless

Model	Required	CL Flying Scale					
Weight	Model Centerline to	Single Strand			Multi-Strand		Pull
Pounds	Handle Grip Length	1 Line	2 Lines	3 Lines	2 Lines	3 Lines	Test
.0 – .75	35' – 52.5'	.010"	.008"	.008"	.010"	.008"	10G
.75 – 1.50	35' – 70'	.014"	.010"	.008"	.012"	.010"	10G
1.51 – 2.50	52.5' – 70'	.014"	.012"	.010"	.015"	.015"	10G
2.51 – 4	52.5' – 70'	.018"	.014"	.014"	.021"	.018"	10G
4.01 – 8	52.5' – 70'	.024"	.018"	.016"	.024"	.021"	5G
8.01 – 12	65' – 70'	.022"	.018"	.016"	.024"	.021"	5G
12.01 – 20	65' – 70'	.026"	.022"	.018"	.027"	.024"	5G

Logic behind proposed change, including alleged shortcomings of the present rules. State intent for future reference.

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New event test data/information (new events only), please provide what testing of this new event has taken place to include number of participants and number of contests.

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Effect, if any, on current AMA records.

There is no effect. AMA does not have a system for CL Scale scoring records.

**Note: The Contest Board Chairman may, in coordination with the submitter of the proposal, at any time prior to submitting a proposal to the Contest Board for Final Vote, edit proposal wording to increase clarity and to avoid ambiguity provided the proposal intent is not changed.**

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Signature: 

Date of Signature: June 30 , 2014