THERMODYNE ENGINEERING LTD.

421 Nugget Ave. Unit 3, Toronto, Ontario, Canada, M1S 4L8
Tel: (416)754-8686 Fax: (416)754-8687
Email: Jyeremian@thermodyne.ca
www.thermodyne.ca

CRYSTAL VALLEY DECORATING INC.

TITAN BANNER BRACKET

QUALIFICATION TEST REPORT FOR 80 MPH WIND

Prepared by: Andre Nguyen, B. Eng. A.N.

Reviewed by: Rafael Bolanos, CET. R.B.

Approve by: Joseph Yeremian, P.Eng.

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REGISTERED PROFESSIONAL ENGINEER
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J. YEREMIAN
PROVINCE OF ONTARIO

CRYSTAL VALLEY DECORATING INC.
TITAN BANNER BRACKET
QUALIFICATION TEST REPORT
FOR
80 MPH WIND

1- SCOPE:

1.1 This report covers the qualification of the Titan Bracket Assembly made by Crystal Valley Decorating Inc. to 80 Miles per Hour (MPH) nominal wind velocity.

1.2 The qualification is done in two stages. In the first stage, the effect of 80 MPH wind was done by calculations to determine the load on the bracket assembly, the second stage was done by testing of the banner assembly for the maximum capability of the banner until failure.

1.3 **Important Note:** The published general wind velocity of environment could be 80 MPH, but the wind velocity in the location of the banner cannot be predicted due to the surrounding buildings and other obstacles, and also the wind velocity is not constant all the time, therefore, this qualification report does not take into consideration the turbulence caused by the wind and the local wind velocity, which may be higher than 80 MPH published by the weather forecast and also the type of the banner which may cause unpredictable effects. Therefore, the qualification of the banner assembly is under static conditions. However, local wind velocities and turbulences may create unpredictable forces on the banner which is not part of this qualification.

1.4 The straps and the frictional forces created by the bracket bonding on any surface is not part of this qualification.

1.5 This qualification is based on having two identical bracket assemblies holding one banner and the wind velocity perpendicular to the face of the banner, where the total force is shared by the two bracket assemblies.

2- CONCLUSION:

The Titan Bracket Assembly can withstand 80 Miles per Hour wind velocity imposed by a banner which is 31” by 83” size, shared by two bracket assemblies..

A- CALCULATIONS:

A-1 Calculation Methods:

The banner bracket assemblies are modeled as a rigid plate with the wind force acting perpendicular to the supports imposing uniformly distributed load on the rod.

Drag Force Method was used for the calculations.

A-2 Drag Force Method:

The drag force method is a measure of force based on the resistance presented by an object impeding flow.

This method is very sensitive to the value of coefficient of drag, which is a function of geometry and typically found experimentally. When the wind blows against the banner it changes the profile of the banner making it concave as it catches the wind. This effect will increase the coefficient of drag, which in turn will increase the drag force. These variations in coefficient of drag are addressed and dealt with in this section.

Drag force as per Fluid Mechanics, 3rd Edition, Streeter, is given as follows:

$$D = \frac{1}{2}\rho A V^2 C_d$$

Where,

D – Drag Force (lbf)	
ρ – Density of air	= 0.07647 lbm/ft^3
A – Projected Area	= 17.87 ft^2
V – Mean Fluid Velocity	= 117.33 ft/s
C_d – Coefficient of drag	= 1.28

The coefficient of drag for a flat plate is given as 1.28 by NASA, shown in Appendix B.

Since the banner will curve during the high wind conditions, and this is a function of the material of the banner, therefore, we are considering in this qualification that the coefficient of drag will be increased by 10%, bringing the C_d to 1.4

The density is given in pound-mass, therefore to convert it to pound-force we need to divide it by the acceleration of gravity, g, given by 32.174 ft/s^2.

Substituting the values:

$$D = \frac{1}{2}\left(\frac{0.07647}{32.174}\right)(17.87)(117.33)^2(1.4)$$

$$D = 409.28 lbf$$

The drag force calculated is the total force acting on the entire banner bracket assembly, which includes two cantilever beams. To determine the force acting on one bracket, the value must be halved:

$$F_{SingleBeam} = \frac{D}{2}$$

$$F_{SingleBeam} = \frac{409.28}{2}$$

$$F_{SingleBeam} = 204.64 lbf$$

The force acting on one cantilever beam (the rod) is therefore calculated to be 204.64 lbf using the Drag Force method. This value will be used to verify the integrity of the banner assembly against the test results.

Increased curvature on the banner can have an affect on the forces acting by the wind, since variations in the coefficient of drag can have an impact on the drag force. A correlation between the coefficient of drag and drag force is developed and presented in figure 1, Appendix A for information. Appendix B includes additional references.

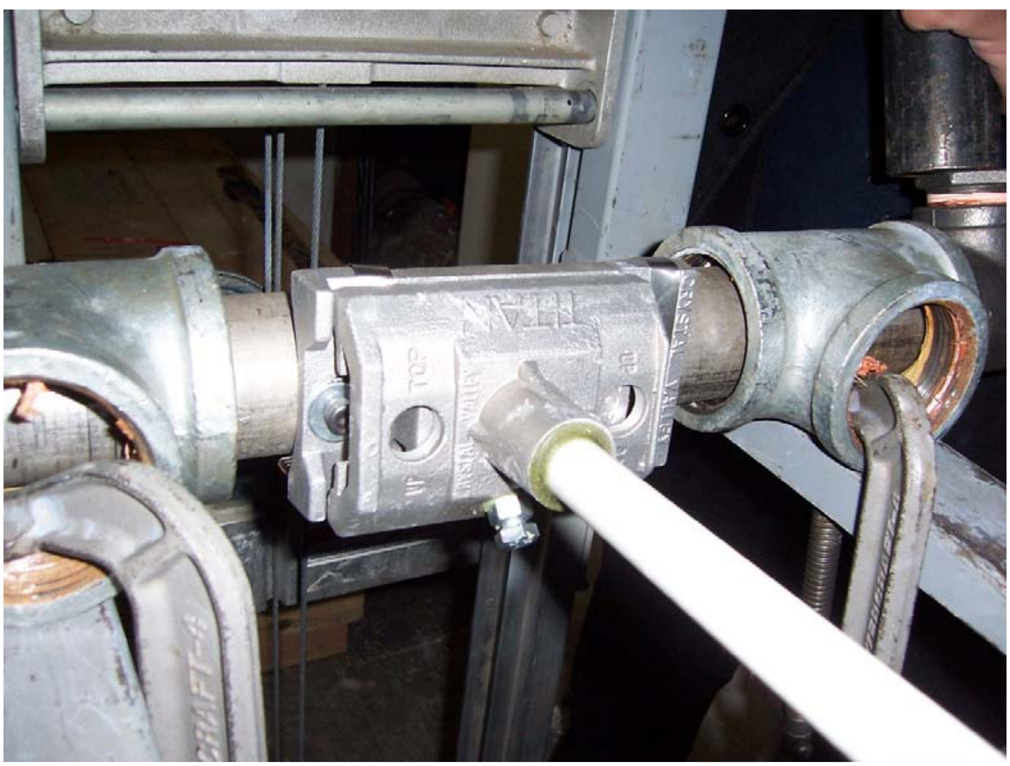
B- TESTING

B-1 TEST SET-UP:

The physical test of the banner bracket assembly was conducted on one of the support beams provided. The force acting on both support beams is assumed to be equivalent; therefore the failure of one would represent the failure of the banner bracket assembly. The banner bracket assembly was fixed and stressed under a uniform, increasing load until failure.

The test setup included a large empty test barrel to be filled with water, held in place by the banner fabric, stitched from end to end, and attached to a single cantilever support beam. The cantilever support beam was fixed on a shaft that was free to rotate. An adjustable lift kept the barrel above ground and a long moment arm attached to one end of the rotating shaft was used to keep the test barrel level. The test barrel was kept level to represent a uniformly distributed load force acting in the perpendicular direction on the banner assembly rod.

The following is a picture of the test set-up:



Assembly Before Placing the Banner with Loads.

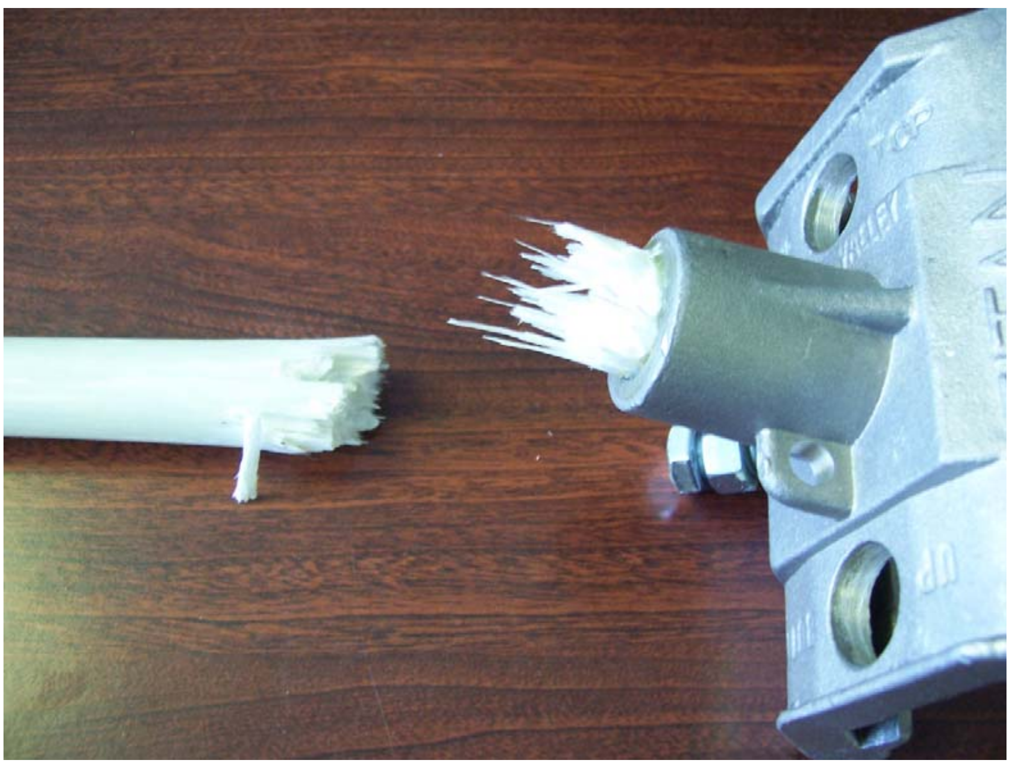
Assembly with load
(blue barrel filled with water wrapped by the decorated banner).

B-2 TEST PROCEDURE:

The test was conducted as follows:

1. The banner bracket was securely fixed in place to rotating shaft to allow the tank that will be filled with water to stay horizontal as the rod of the assembly was bending during loading.
2. A banner was installed on the rod of the banner bracket assembly to as cantilever beam with the test barrel inside it. A tie was used at the base of the banner to prevent it from slipping from the rod as the rod was deflecting.
3. The barrel was slowly filled with water, thus increasing the load on the cantilever beam with infinite graduations.
4. The barrel was constantly monitored to ensure it was level and applying a force perpendicular to the rod.
5. The barrel is filled with water until the rod failed under the load.
6. Once failure occurs, the barrel is removed, its water contents measured and the empty weigh of the barrel was added to determine the failure load in pounds. The results are documented below.

The following is a picture of the failed rod:



View of the Failed Rod.

RESULTS:

The banner bracket assembly was tested based on the procedure and test setup outlined in the PROCEDURE section. Two trials were conducted and the results are as follows:

Test No	Failure Load
1	254 lb
2	319 lb

In Test No. 1, portion of the rod sheared off before being broken, but the rod did not bread. A second rod was used for Test No. 2, this time the rod broke completely as shown in the picture above.

Based on the CALCULATIONS section, the force determined from The Drag Force Method is used to compare the failed load to the force acting on the rod at 80 miles per hour.

The Drag Force Method calculated the force acting on one support beam with a wind velocity of eighty miles per hour to be: 204.64 lbf whereas the rod failed at: 254 lbf Therefore, there is a safety margin between the qualified 80 MPH wind and the rod failure by 24.12% till the rod shears off before failure and a safety margin of 45.5% before the rod breaks.

Notes:

1- There was no failure or deformation of any other part of the banner assembly. As noted before, the straps are not part of the qualification of the banner assembly.

2- Consideration should also be given to the quality of the rod material during production so that material characteristics should not be inferior to the one supplied and tested.

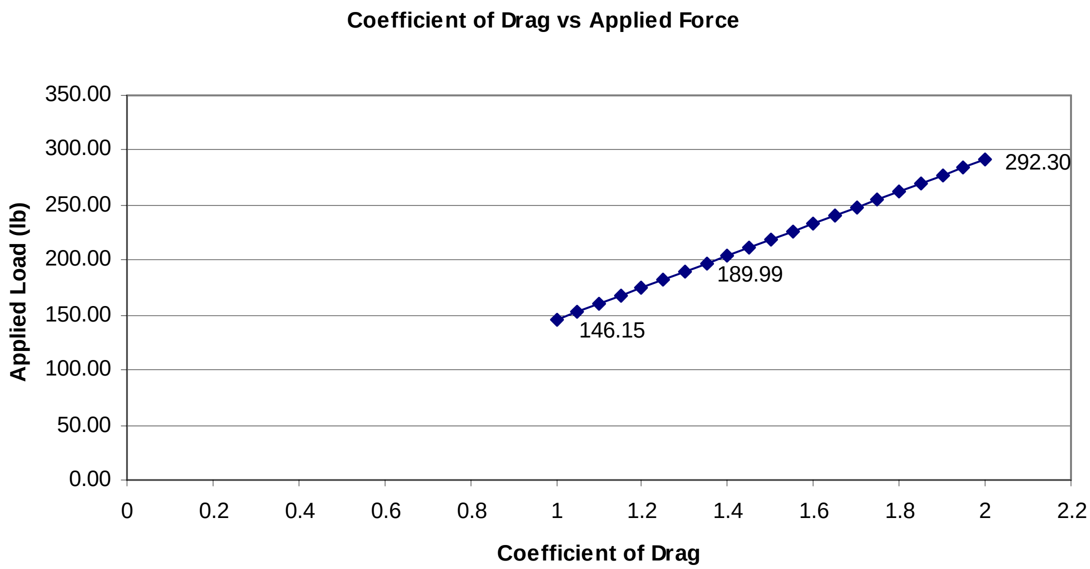
CONCLUSION:

The Banner Assembly was tested for qualification for winds of up to 80 miles per hour. The calculations are based on the Drag Force Method. The Titan banner bracket assembly has a safety margin of 45.5% before the rod breaks.

Based on the test results, the design of the Titan banner bracket support will therefore withstand wind forces of up to 80 mph for a banner of size 31 by 83 inches. Any banner with a smaller surface area and aspect ratio meets this requirement.

APPENDIX A - FIGURES

FIGURE 1:



APPENDIX B - REFERENCES

1. Fluid Mechanics, 3rd Edition, Streeter

Dryden[1] has correlated the turbulence level of the fluid stream to the Reynolds number for the sphere at $C_D = 0.30$. The greater the turbulence of the fluid stream, the smaller the Reynolds number for shift in separation point.

5.6. Drag on Immersed Bodies. The principles of potential flow around bodies are developed in Chap. 7, and principles of the boundary layer, separation, and wake in the section preceding this one (Sec. 5.5).

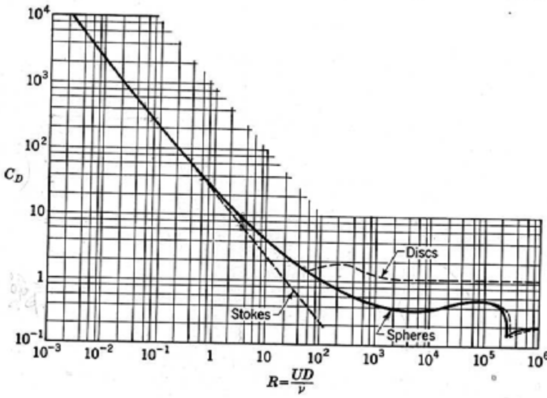


FIG. 5.23. Drag coefficients for spheres and circular disks.

In this section drag is defined, some experimental drag coefficients are listed, the effect of compressibility on drag is discussed, and Stokes' law is presented. Lift is defined and the lift and drag coefficients for an airfoil are given.

Drag is defined as the force component, parallel to the relative approach velocity, exerted on the body by the moving fluid. The drag-coefficient curves for spheres and circular disks are shown in Fig. 5.23. In Fig. 5.24 the drag coefficient for an infinitely long circular cylinder (two-dimensional case) is plotted against Reynolds number. This case also has the sudden shift in separation point as in the case of the sphere. In each case, the drag coefficient C_D is defined by

$$\text{Drag} = C_D A \frac{\rho U^2}{2}$$

in which A is the projected area of the body on a plane normal to the flow.

[1] H. Dryden, Reduction of Turbulence in Wind Tunnels, *NACA Tech. Rept.* 392, 1931.

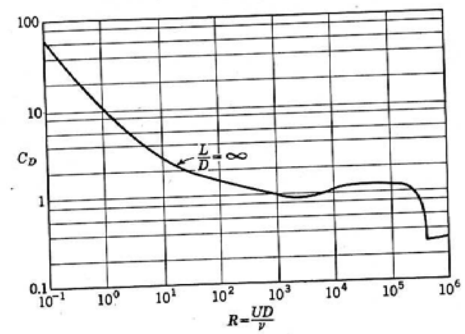


FIG. 5.24. Drag coefficients for circular cylinders.

TABLE 5.1. TYPICAL DRAG COEFFICIENTS FOR VARIOUS CYLINDERS IN TWO-DIMENSIONAL FLOW†

Body shape	C_D	Reynolds number
Circular cylinder →	1.2	10^4 to 1.5×10^5
Elliptical cylinder → 2:1	0.6	4×10^4
	0.46	10^5
→ 4:1	0.32	2.5×10^4 to 10^5
→ 8:1	0.29	2.5×10^4
	0.20	2×10^5
Square cylinder →	2.0	3.5×10^4
→	1.6	10^4 to 10^5
Triangular cylinders → 120°	2.0	10^4
→ 120°	1.72	10^4
→ 90°	2.15	10^4
→ 90°	1.60	10^4
→ 60°	2.20	10^4
→ 60°	1.39	10^4
→ 30°	1.8	10^5
→ 30°	1.0	10^5
Semitubular →	2.3	4×10^4
→	1.12	4×10^4

† Data from W. F. Lindsey, *NACA Tech. Rept.* 619, 1938.

In Table 5.1 typical drag coefficients are shown for several cylinders. In general, the values given are for the range of Reynolds number in which the coefficient changes little with Reynolds number.

A typical lift and drag curve for an airfoil section is shown in Fig. 5.25. Lift is the fluid-force component on a body at right angles to the relative

2. NASA: http://www.grc.nasa.gov/WWW/K-12/airplane/shaped.html