# Environmental Conditions & Safe Operating Limits:

Name: _____ Date: _____

## Introduction

In addition to determining a number of other variables such as: the size of the crane, how large the pad needs to be, the maximum load that crane can lift, and the sling load – Engineers and crane operators will also need to determine environmental limits for the safe operation of a crane.

A gentle breeze may not seem like much to someone standing on the ground; however, a gust of wind can cause a load to start swinging. If the swinging action of the load gets out of control it could cause strain on a crane that it was not designed for. This could cause the cable to snap and the load crash to the ground, or even worse, it could cause the entire crane to collapse.

In this activity we will look at how to calculate the effects that wind has on a load using "wind resistance coefficients". Using the following equation, we will be able to determine the maximum wind-speed which the crane can safely be operated under.

$$V_{Max} = V_{Chart}\sqrt{\frac{T_s \; x \; M}{A_P \; x \; C_w}}$$

## Variables

There are 6 variables in this equation. While some variables need to be calculated, other variables can be looked up in the provided charts.

$V_{max}$ = Maximum Permitted Windspeed
$V_{Chart}$ = Maximum Wind Speed For Crane
$T_s$ = 1.2 (Manufacture Test Standards: EN 13000 – 2010 / ISO 4306-2:2012 )
M = Maximum Gross Weight
$A_P$ = Sail Area of Load
$C_W$ = Resistance Coefficient

Using this equation we can determine "$\mathbf{V_{Max}}$" which is the maximum windspeed in "m/s" which the load can safely be lifted. This is slightly different than the "$\mathbf{V_{Chart}}$" value which is a limit that has been set by either the manufacture of the crane based on testing, or by a government authority. The difference between the 2 is that "$\mathbf{V_{Chart}}$" does not take into consideration the size, weight, or wind resistance of a particular load; therefore, "$\mathbf{V_{Max}}$" is a revised value that provides a safe operational limit specific to a particular load's size, shape, and mass.



## Practice Problems

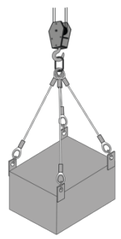
1. Determine "$\mathbf{V_{Max}}$" for the following two scenarios if the recommended limit when controllable factors are considered is used.

   a) A pre-fabricated section of a tower that is made of concrete is being lifted by a crane. It has a total mass of 6tons and a side surface area of 32m$^2$. What is the "$\mathbf{V_{Max}}$" for this load?

   ***Calculations:***

   b) An electric generator that has been packed inside a crate is being lifted by a crane. The weight of the generator is 12tons and the create measures 5x7 meters. What is the "$\mathbf{V_{Max}}$" for this load?

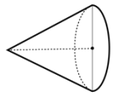
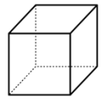
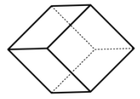
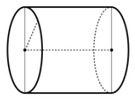
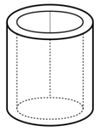
   ***Calculations:***

2. Explain why would various objects have a different "wind resistance coefficients".
   _____
   _____
   _____

### Generic "$V_{Chart}$" Values

12.0m/s = The recommended limit when controllable factors are considered
***16.5m/s* = *The maximum limit set by the UK government***
17.0m/s = The maximum limit when factors harmful to humans are considered
20.0m/s = The maximum limit that is used in most countries

### Drag Factor Look Up Table

| Image | Shape | Wind Resistance Coefficient |
|---|---|---|
|  | Sphere | 0.47 |
|  | Half Sphere | 0.42 |
|  | Cone | 0.50 |
|  | Cube | 1.05 |
|  | Angled Cube | 0.80 |
|  | Long Cylinder | 0.82 |
|  | Hollow Cylinder | 1.20 |



### Guided Example

**Step 1:**
Always start by writing the equation so you know what variables you need to find or calculate before substituting values.

$$V_{Max} = V_{Chart}\sqrt{\frac{T_s \; x \; M}{A_P \; x \; C_w}}$$

**Step 2:**
Substitute all of the known values. For this example, we assume a load that it has a shape similar to a cube or rectangle, has a mass of 8tons, and has a side area equal to 45m$^2$. If any of these values are unknown (i.e. sail area of the load) then they need to be calculated first (i.e. "length x width").

$$V_{Max} = 12m/s\sqrt{\frac{1.2 \; x \; 8}{45 \; x \; 1.05}}$$

**Step 3:**
Use standard mathematical conventions to simplify and solve the equation. It is always best to show all of your work. This makes it much easier for someone to check your work if all of your steps are clearly shown. This will also likely be a requirement by safety inspectors as well so get used to taking the time to do the math properly.

$$V_{Max} = 12m/s\sqrt{\frac{9.6}{47.25}}$$

$$V_{Max} = 12m/s\,\sqrt{0.20}$$

$$V_{Max} = 12m/s \; x \; 0.45$$

**Step 4:**
The final "**$V_{Max}$**" value is the revised safe limit for lifting the load. It should be stated in terms of "__ m/s".

$$V_{Max} = 6.0m/s$$

In this example we have determined the new operational limit for a specific load. That is the maximum windspeed that can be present if the load is to be safely lifted. Therefore, for this particular load, the maximum windspeed must not exceed 6.0m/s.