

## **Energy – CRASH3 (CRUSH5 – Delta V from Damage)**

**Overview:** Uses enhanced Crash3 Damage Analysis algorithms to compute collision data including Delta V (change of velocity) for the collision.

### **Entry into Module:**

This module of the program is normally entered by clicking on the **REC-TEC** block in the upper left of the **REC-TEC Window** causing the drop-down menu to appear. Place the cursor on the **Energy** block and click on **CRASH3 (CRUSH5 – Delta V from Damage)** on the sub-menu to initiate this module.

Under certain circumstances, the user may choose to use the **Files** block instead of the drop-down menu approach. Selecting any file with a **.CRS** extension in the **Dialog box** accessed from either the **Open Single File** or **Open Multiple Files** block opens this module.

Selecting **AutoLoad [ON]** from either the **Setup Menu** or the **AutoLoad Icon** on the upper right side (third line) of the **REC-TEC Window** automatically loads the two-vehicle scenario that was on the screen when the module was closed, either individually, or when the program was closed. With **AutoLoad [OFF]** on the main **REC-TEC Window**, modules will start without loading a file. Use **AutoLoad [OFF]** and manually load the file if only one vehicle is involved.

### **Data Entry:**

This module contains the following data entry blocks:

#### **Crush5**

- **Centroid:**
  - **RT** – REC-TEC Equations for Centroid
  - **PE** – Parkka Equations for Centroid
  - **ME** – Mitchell Equations for Centroid
  
- **Vehicle:**
  - **Vehicle 1**
  - **Vehicle 2** (If second vehicle)
  
- **Description** – Vehicle (N) Description (Optional)
  
- **Category**
  - **Default** – Sets defaults for Entered Vehicle Category
  - **Textbox** – Entry of Category for Vehicle (Zero for no Category)
  
- **Weight** – Weight of Vehicle

- **Damage Width** – Width of Damage (L)
- **Damage Offset** – CG is reference point. If damage is forward or right, use a positive value; if rearward or left, use a negative value.
- **PDOF** – 0 to +/- 180 degrees 0 = Front, 180 = Rear, -90 = Left, +90 = Right
- **Stiffness A** – Stiffness Coefficient A
- **Stiffness B** – Stiffness Coefficient B
- **Stiffness G** – Computed

#### **Surface (Damage)**

- **Front**
- **Rear**
- **Right**
- **Left**
  
- **Yaw Radius of Gyration** – Blank to have program compute
- **Wheelbase** – Front axle to Rear axle
- **CG – Front Axle** – Distance from CG to Front Axle
- **CG – Front** – Distance from CG to Front
- **Vehicle Length** – Length of Vehicle
- **Vehicle Width** – Width of Vehicle

#### **Optional Data (for Scale Diagram in Graphics only - does not enter computations)**

- **Front Track**
- **Rear Track**
- **Tire Radius (F)**
- **Tire Radius (R)**
- **Tire Width (F)**
- **Tire Width (R)**

#### **Crush Measurements (2 minimum / 20 maximum)**

- **C01 to C20** - Use as required
- **L01 to L20** – Cumulative Distance from **L01**. **L01** is always Zero (**0**).
- **% (19)** – Weight for Segment as percent (1 to 100) defined by adjacent “C” measurements

#### **Non Linear Crush5 Functions (Check to Enable)**

- **Percent of “C” Measurement**
  - **Zone (1 to 3)** – Length of “C” enables defining three separate Zones
  - **Percent** – Weight for Zone as percent (1 to 100) defined by length of “C” measurements
- **Inches of “C” Measurement**
  - **Zone (1 to 3)** – Length of “C” enables defining three separate Zones

- **Percent** – Weight for Zone as percent (1 to 100) defined by length of “C” measurements

### **Test Collision Data** (Used to compute A, B & G Stiffness Coefficients)

- **Crush Energy Equivalent Speed** – Exemplar Vehicle in Test Crash
- **Maximum CEES without Permanent Damage**
- **Average Crush – Enter 0 (Zero) to Compute**
  - **Number of “C” Measurements**
  - **Length of (Each) “C” Measurement**
- **Test Vehicle Weight** – Exemplar Vehicle in Test Crash
- **Test Vehicle Damage Width** – Exemplar Vehicle in Test Crash

### **Collision Force Error**

- Two light yellow Command Buttons with the Collision Force for **Vehicle 1** and **Vehicle 2** appear in the **Crush5 Analysis** Output frame if there is an imbalance of the Collision Forces between the vehicles. Click on the Collision Force to be changed to engage a frame that shows the information required to balance the Collision Forces of the vehicles
- A light blue Command Button (=) allows the user to average the (Peak) Collision forces of the two vehicles and use this average Force to compute new A and B Stiffness values for the vehicles balancing the Collision forces..

### **Output:**

#### **Central Collision**

- **Crush Energy** – Energy required for Damage
- **Equivalent Barrier Speed** – Speed of Central Collision with Barrier required to cause damage.
- **Mass** – Mass of vehicle
- **Yaw Radius of Gyration** – Computed or Supplied
- **Inertia Moment (Mass \* Radius of Gyration)** – Resistance to Rotation
- **CoD (X) – Depth** – Depth measurement - Similar to “C” measurement
- **CoD (Y) – Width** – Width measurement - Similar to “L” measurement
- **Damage Area** – Computed area of Damage
- **Moment Arm (Length)** – Lever Arm through which Force acts on CG
- **Gamma (Y) Value** – Equivalent Mass
- **Linear Impulse** – Equal Magnitude and Opposite Direction
- **Collision Force – Peak** (See **Collision Force Error** above)
- **Energy - Dissipated** – As Damage (Individual Vehicle)
- **Energy - Dissipated (Total)** – As Damage for both vehicles combined

- **Energy - Maximum** – Maximum Available for Damage, Rotation and Motion (Translational)
- **Delta T** – Linear Impulse / Average Collision Force
- **G (Acceleration Factor)** – Computed
- **Speed- Closure** – Closing Speed of Vehicles
- **Speed – Equivalent Barrier** – Reduced Mass (non-Central) Barrier Speed

### Delta V

- **Delta V (Angular)** – Angular Rotation – A negative number indicates a Counter-Clockwise rotation
- **Delta V (Angular)** – Angular Rotation – A negative number indicates a Counter-Clockwise rotation
- **Delta V (Longitudinal)** – Longitudinal Vector Change (Speed and/or Direction)
- **Delta V (Lateral)** – Lateral Vector Change (Speed and/or Direction)
- **Delta V (Total)** – Total Vector Change (Speed and/or Direction)

### Text files for CAD conversion to .dxf files:

- **Vehicle1.ASC and Vehicle2.ASC** – These files are text files that most CAD programs can import and convert to .dxf files. This will allow the user to export files with the damage profiles and vector data as they appear in this module for direct conversion to .dxf files. If vehicle data from **AutoStats** or **Autostats Lite** is imported into **CRUSH**, those vehicles, drawn to scale with scale damage, can be exported and converted. These files are created when the **Graphics** are displayed.

### Options:

Several **Command Buttons** appear in a frame located at the lower right corner of the module Window. The **Command Buttons** allow the user to engage options including the option to **Open** and **Save** the data (for **Vehicle 1** and **Vehicle 2**) required to generate the scenario shown on the screen at the time the file was saved.

- **Open .CRS File** – Calls up a **Dialog box**, which **Opens** any pre-existing .CRS file and displays the output results.
- **Save .CRS File** – Calls up a **Dialog box**, which **Saves** data on the screen to files with any user-selectable filenames. This is independent of the automatic saving as “LastFile.CRS” of the data at the close of this module or the close of the program.
- **Exemplar Test** – Computes **A**, **B**, and **G** coefficients of Stiffness (see Inputs above)
- **Graphics Suite** – Graphic display of each vehicle, both vehicles side-by-side and

both vehicles positioned with the centroids overlapped. Vector lines show PDOF, moment arms and DeltaV direction. [Esc] to Exit

- **Formulae** – Opens a word processor (set by the user in **Setup**) with a file showing the basic formulae use in this module of the program. While the user may add to or modify the information in this file, it does not change the formulae imbedded into the program.
- **N** – This button toggles a graphical number pad on the screen that can be used to enter data into the input boxes without using your keyboard number pad. This may be useful for presentations as data entry can be accomplished using a wired/wireless mouse.

#### **Additional Information:**

##### ***CRASH3 Technical Manual – Internet***

**IPTM Publications** – The following publications are available from **IPTM 1-904-620-4786** or <http://www.iptm.org> and are recommended for further reading.

***ANATOMY of a COLLISION*** by George M. Bonnett contains an article entitled **Stiffness Coefficients – Energy and Damage**, detailing this process.

***UNDERSTANDING DELTAV FROM DAMAGE*** – Discussion includes **Crash3** formulae and computations for non-equidistant "C" measurements.

***BEYOND CRASH3 -- DELTAV FROM DAMAGE*** - Discussion of depth "zones" for non-linear crush and modeling of bullet-shaped or curved vehicles.