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CLASSIFICATION	SYSTEM NUMBER 507718
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TITLE

DREA DROP TOWER ELECTRONICS CONVERSION

System Number:

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DREA CR/97/446

DREA DROP TOWER ELECTRONICS CONVERSION

by

K.J. KarisAllen

FACTS ENGINEERING Inc.
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B3R 2K9

CONTRACTOR REPORT

Prepared for

Defence Research Establishment Atlantic

Centre de Recherches pour la Défense Atlantique

Canada

National Defence
Research and Development Branch

Défense nationale
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Accepted by : J.R. Matthews
J.R. Matthews - Contract Scientific Authority

W7707-7-4451/001-HAL
Contract Number

October 1997

CONTRACTOR REPORT

Defence Research Establishment Atlantic

Centre de Recherches pour la Défense Atlantique

Canada

Abstract

A system for capturing and analyzing the load/time signals generated during a drop tower impact event has been developed and calibrated using static calibration techniques. The calibration factors for the four ranges available to this system were 624.86 kN/V, 318.00 kN/V, 117.01 kN/V and 63.89 kN/V. The total impact energy of ASTM E604 specimens fabricated from CSA G40.21 350 WT and tested at 1.5 m/s were within the scatter band of these previously characterized specimens.

Résumé

Un système de saisie et d'analyse des signaux de charge/temps générés pendant la chute d'un échantillon depuis une tour d'essai a été élaboré et étalonné à l'aide de techniques d'étalonnage statique. Les facteurs d'étalonnage pour les quatre plages disponibles du système étaient les suivants : 624,86 kN/V, 318,00 kN/V, 117,01 kN/V et 63,89 kN/V. L'énergie totale d'impact des éprouvettes ASTM E604 fabriquées conformément à 350 WT de la norme CSA G40.21 et mis à l'essai à 1,5 m/s était dans la frange de dispersion de ces éprouvettes déjà caractérisées.

TABLE OF CONTENTS

1.0 INTRODUCTION

In order to qualify structural steel and weldments for use in the fabrication of marine structures, they must pass test procedures which impose conditions that exceed expected operational service requirements. For naval marine structures, DREA has relied heavily on the specimen geometry and procedural protocol published in ASTM E-604. E-604 is an impact test where total absorbed energy or thickness of the shear lip provides an indication of the material system's ability to perform suitably under service conditions. Absorbed energy is calculated from the dynamic load/time record captured using accurate, high speed instrumentation. The current system at DREA [1] captures conditioned voltage /time data on a Nicolet Explorer II Oscilloscope. The digitized data is subsequently bussed to a Tektronics 4054 microprocessor where it is converted to load/displacement data. The current system is becoming unserviceable due to the unavailability of parts to repair the existing electronics. This report details the conversion of the existing outdated drop tower software/hardware electronics to a 80586 PC based system.

2.0 TECHNICAL BACKGROUND

The information recorded during an instrumented impact test is the signal produced by a calibrated load cell (tup) with respect to time [2]. To convert the force/time data to force/displacement, the velocity at each moment must be known.

If system friction is assumed to be negligible, the initial impact velocity may be calculated from the initial height of the hammer assembly as:

$$V_o = \sqrt{2gh_o} \tag{1}$$

As the specimen is contacted, there is a loss of energy and an associated loss of velocity, as follows:

$$m\int VdV + mg\int dh - \int P_a V_a dt = 0 \tag{2}$$

The energy absorbed by the specimen (represented by the third term) is approximated by the area from time i to i+1 under the force time curve multiplied by the average velocity from time i to i+1. The second term calculates the potential energy converted to kinetic energy due to vertical displacement of the striker assembly. In this manner, the velocity can be calculated for all times and the time can be converted to displacement by continually dividing time increments by the average calculated velocity during these periods.

3.0 SYSTEM DESCRIPTION

3.1 Hardware Requirements

- IBM 586 compatible microprocessor
- SVGA terminal
- Microsoft compatible mouse
- 101 Enhanced keyboard
- Gage Applied Sciences Inc CSLITE (16K A/D board)
- Vishay 2300 Signal Conditioner/Amplifier

A schematic of the hardware interconnections is shown in Figure 1. Connect the TUP cable to the back panel connector labelled INPUT on the Vishay 2311 signal conditioner/amplifier (for pin out specifications refer to the ETI and Vishay User Manuals). The CSLITE A/D board is installed into an ISA slot on the PC 586 mother board and the back panel output BNC connector labelled TAPE on the Vishay 2311 is connected to the CSLITE back panel connector labelled CH A (use a shielded BNC connector).

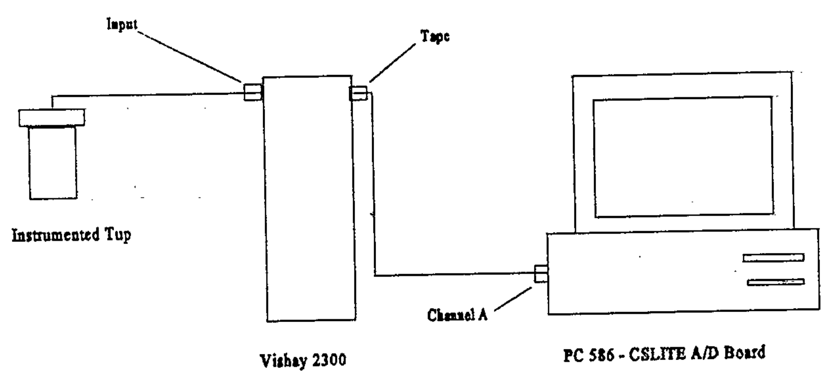

Figure 1 - Schematic representation of DREA instrumented impact test system hardware configuration.

3.2 Software Requirements

The software package consists of a single executable " DREADT.EXE" and two dynamic link libraries "CW3215.DLL" and "GAGE3DRV.DLL" which combine to generate a custom designed virtual instrument which executes the acquisition and analysis of impact force - time data. The system was designed for a 32 bit environment such as Windows 95 or Windows NT and will not execute properly in 16 bit environments such as DOS or Windows 3.1. If the custom software requires reinstallation, the following steps should be followed:

a) Insert the installation disk into drive A:

b) Enter the command A:INSTALL<CR> from the keyboard (this can be done from either DOS or Windows environments).

Once the software has been reloaded onto the system, make sure that the data file "cal.txt" file contains the proper calibration factors. This file can be viewed using a commercially available text editor (not a word processor). A detailed listing of the program source code is provided in the separately bound PART II of this report.

3.3 Calibration Procedure

The instrumented impact system requires periodic calibration verification of the force transducer to ensure the accuracy of the data. This verification is achieved through a static calibration procedure.

1. Attach the tup to the conditioner input and a voltmeter to the output of the conditioner as detailed in the System Description section.

2. Apply an axial compressive load to the instrumented tup using a calibrated servo hydraulic test system or comparable device.

3. Record the calibrated load versus the output voltage at a minimum of ten positions over the full scale range. Plot the data and visually verify the linearity of the force-voltage output.

4. Determine the calibration coefficient in units of kN/volt

5. Repeat steps 2-4 for each system amplifier range/excitation voltage combination used by the system.

6. Update the "cal.txt" file located in the system root directory with the current calibration coefficients.

Using this procedure, a series of calibration factors representing various load ranges were generated. The raw data used as input to the regression analysis is given in Appendix B. A summary of the information in Appendix B is given in Table 1 and shown graphically in Figure 2.

Table 1 - Current system calibration factors

Instrument ID	Calibration Factor (kN/Volt)	Full Scale Load Range (kN)	Amplifier Excitation Voltage (Volts)	Amplifier Gain
E5/G10	624.86	624.86	5.0	10
E1/G100	318.00	318.00	1.0	100
E2.7/G100	117.01	117.01	2.7	100
E5/G100	63.89	63.89	5.0	100

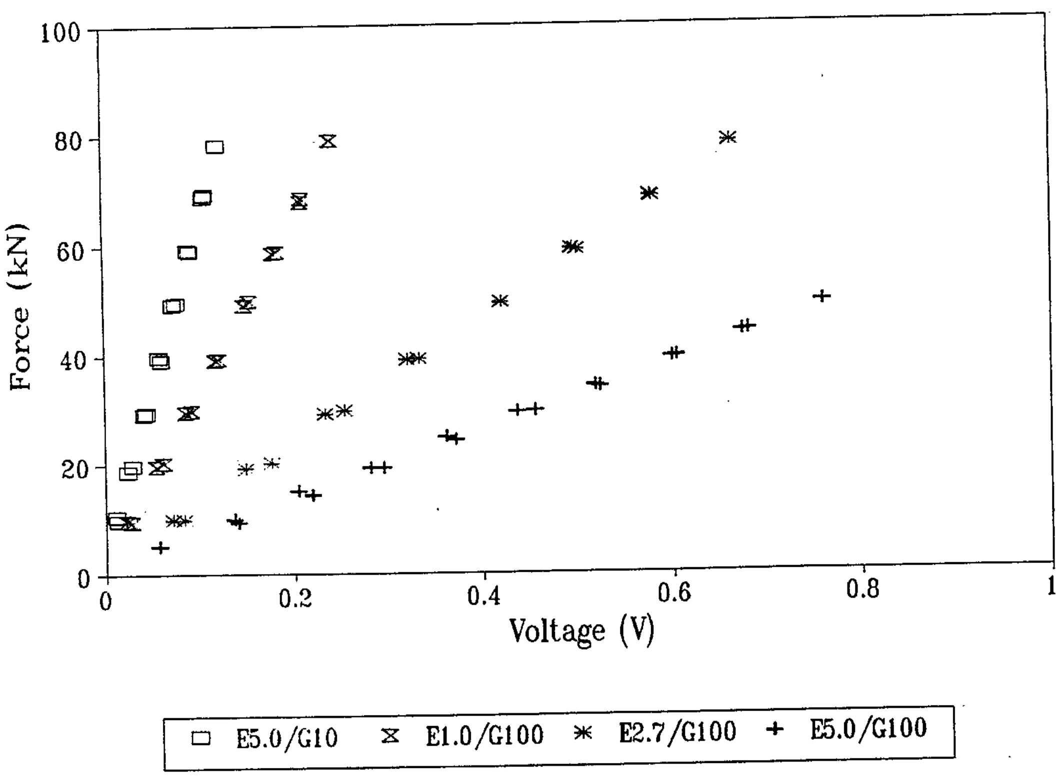

Figure 2 - Calibration curves (force versus voltage) for the four system transducer ranges.

As prescribed in ASTM E-04, transducer verification/calibration should be performed once a year. If the calibration coefficients vary more than 1% from the previous calibration coefficients, then this period should be decreased to 6 months. Also, the Vishay 2311 automatically monitors the resistances in the force transducer. If gauge resistances are mismatched between 1%-5%, the yellow HI LED will be activated. If the gauge resistances are mismatched by more than 5%, the yellow HI LED blinks indicating a serious transducer problem. Changes in transducer resistances should result in an immediate recalibration of the system.

4.0 GETTING STARTED

The DREA instrumented impact testing system is a R&D oriented software package designed for gathering and analysing dynamic force time data. Once the system has been configured, data base generation and maintenance is self supervising. Using this system requires no previous experience with computers. The system has a single control display which allows the operator complete access to the program functions. To initiate the program and generate the control display, choose the DREADT icon from the Windows program menu.

A schematic of the user interface associated with this program is shown in Figure 3. The display is divided into four sections. The column of windows located on the left hand side of the display are for the input of client, test apparatus, test specimen and procedure description. While these variables do not effect the acquisition of the data, several are used for post processing the data from load/time to load/displacement. The variables associated with these windows can be up to 100 characters long. The initial screen displays the data types associated with each of the windows.

The bottom centre/right section of the screen contains various check boxes, scroll bars and track bars which are used to set up and control the digitizer during data acquisition. The operator can set test parameters such as transducer range, digitizing rate, channel trigger source, channel storage location, trigger level and the trigger delay. The system has been preprogrammed with valid CSLITE settings to minimize operator error during digitizer setup.

The upper centre/right section of the screen contains the check boxes and track bars used to activate data capture and control post processing of the data display located immediately below these controls. The operator can define the point of initial impact and final fracture. The data can also be scanned by the operator using the cursor option.

The final section of the display is the command menu located along the top of the display. The command menu allows the operator to input variables from ASCII text files as well as output captured data to either ASCII text files or to a hardcopy device such as a printer or plotter. The command menu also has an online help section to assist the user to correctly configure and calibrate the hardware as well as set up and capture data using the software interface. The following sections detail data input, data capture/post processing and data output.

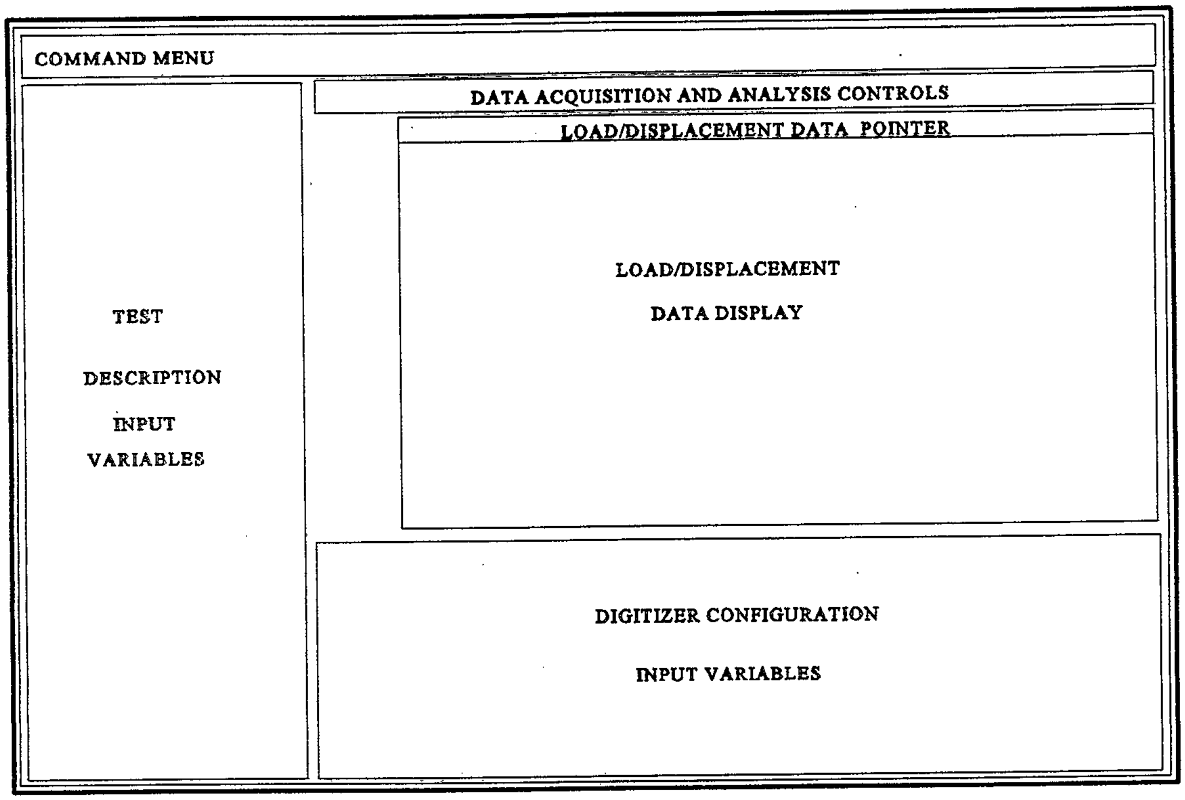

Figure 3 - Schematic of DREA instrumented impact test system user interface.

4.1 Data Input

There are three methods available for inputting configuration data to the system. Upon system initialization, the user can manually enter data into the description variables and digitizer control buttons. Alternatively, if a variable data file was saved previously "ID.var"(section 4.3), then this file can be recalled to automatically configure the system to the previously saved configuration. In a similar manner, a variable/test file "ID.tim" (this is the file saved at the successful capture of impact data) can be recalled to automatically configure the system. The basic procedure for inputting a file is the same regardless of file type. This is given as:

a) Choose FILE/OPEN from the command menu.
b) Set the file type using the file type menu.
c) Click on the name of the file to be opened.

d) Click on OK box in the Open File window box.

Regardless of the manner in which the system is configured, the system should now be ready for data capture.

4.2 Data Capture and Post Processing

Once the system has been properly configured (see section 4.1), the digitizer can be activated by clicking on the "SET TRIGGER" button. The system will remain activated for 20 seconds. If the trigger level conditions are met, then the system will capture the load/time trace and display the trace on the terminal. If the trigger condition times out, a message to this effect will appear on the screen. ***Immediately upon the successful capture of an impact trace, save this file (section 4.3) to avoid the possible loss of valuable data.***

Post processing of impact data is achieved using the "ZERO", "END", and "CALCULATE" buttons combined with the graph track bar located at the top of the graph. The point of impact can be selected by clicking on the "ZERO" button. Pulling the track bar pointer in combination with the keyboard arrow keys is used to isolate the position of initial impact. Accurately defining the point of initial impact is necessary in order to define the initial velocity conditions for the numerical algorithm which converts load/time to load/displacement using conservation of energy principles. The point of final fracture can be similarly defined by clicking on the "END" button and using the track bar and keyboard arrow keys. The system has data boxes to display force and displacement values associated with the zero and end positions.

4.3 Saving and Printing Data

There are three differing type of files which the operator can save to disk storage. File structures for these different types of files are given in Appendix A. The first type is a test variable file which saves the current settings of the test description and digitizer configuration variables. This file is saved using the ".var" file descriptor (adjust the file type list to the "*.var"). The second and probably the most commonly saved type of file is the load/time data file. Saving load/time data is done immediately after the successful capture of a new instrumented impact record. This file is saved using the ".tim" file descriptor (the "*.tim"file type is the default setting). If the operator requires a data file containing load/displacement couplets for the displayed data, this can be achieved by saving the file using the ".lpd" file descriptor (adjust the file type list to the "*.lpd"). This data file type can be imported into most commercially available spreadsheet and graphing packages. The basic procedure for saving a file is the same regardless of file type. This is given as:

a) Choose FILE/SAVE from the command menu.
b) Set the file type using the file type menu.
c) Input the name of the file to be saved (include the file descriptor).
d) Click on OK box in the Save File window box.

A hardcopy of the data currently being displayed can be obtained by choosing the FILE/PRINT option from the command menu.

5.0 EXPERIMENTAL VERIFICATION OF INSTRUMENTATION

To provide an experimental verification of the accuracy of the system developed, 8mm thick specimens of CSA G40.21 350WT were tested in the L-T and T-L orientations. Dimensional measurements and tolerances in accordance with ASTM E-604 were observed. The three-point-bend specimens were impacted at 1.50 m/s with a 275 kg crosshead. The signal from the instrumented transducer was routed to the Vishay 2311 signal conditioner/amplifier. The amplified signal was routed from the amplifier to the 8 bit digitizer where the signal was captured and stored for subsequent analysis. Figures 4 and 5 are the load/displacement records for the L-T and T-L orientations, respectively. The total impact energy for the L-T orientation was 446 Joules while T-L impact energy was 247 Joules. Both these values were within the scatter associated with these previously characterized specimens.

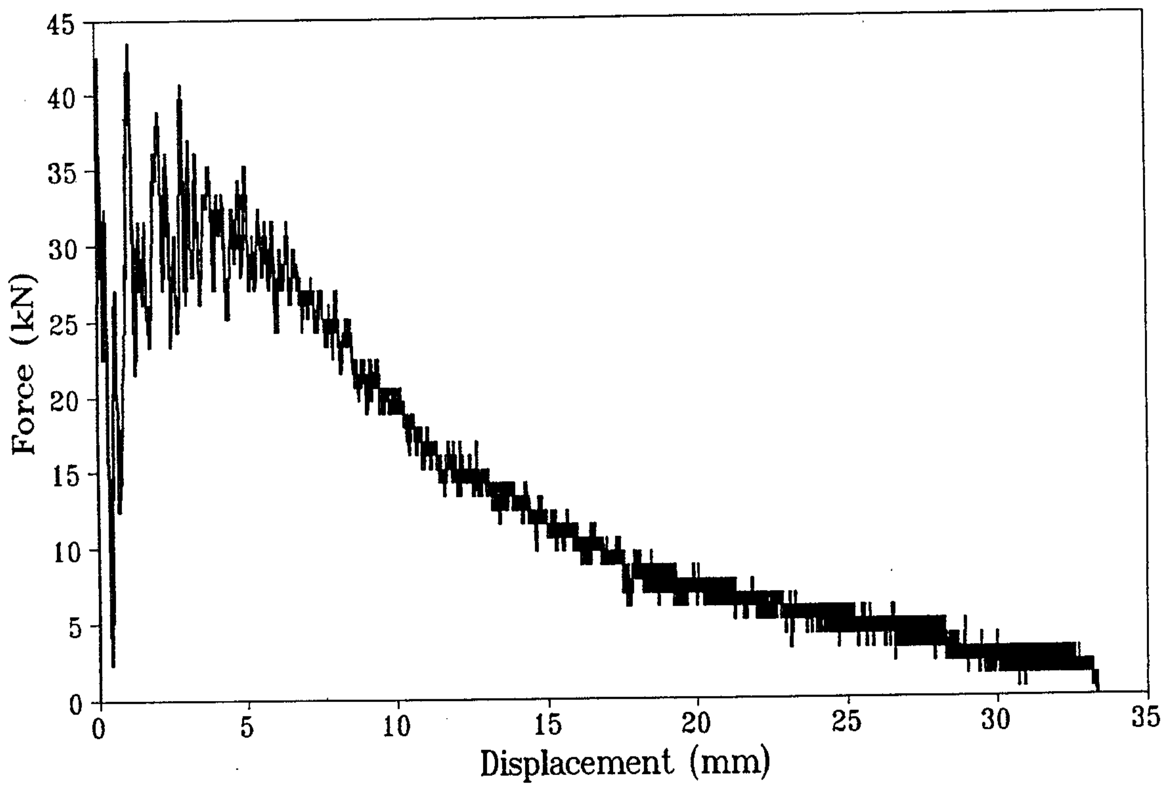

Figure 4- Load/Displacement record for a 8 mm CSA G40.21 specimen in the L-T orientation impacted at 1.5 m/s.

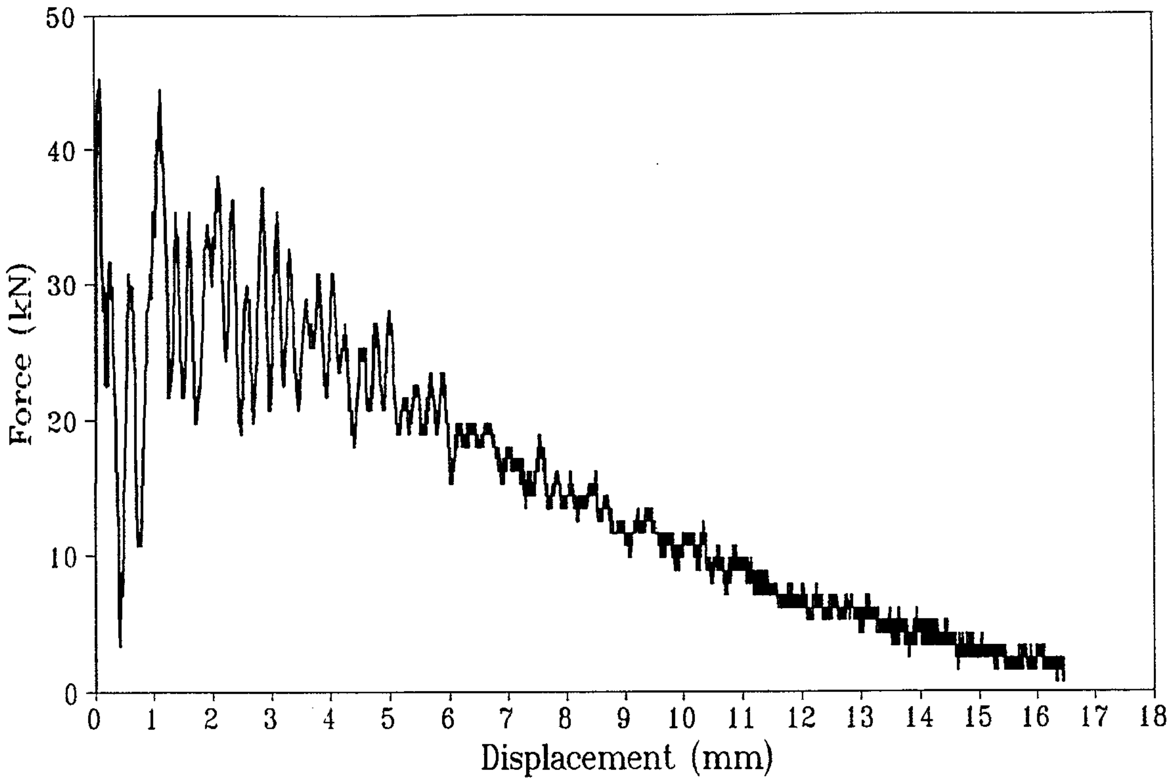

Figure 5- Load/Displacement record for a 8mm CSA G40.21 specimen in the T-L orientation impacted at 1.5m/s

6.0 CONCLUSIONS

A system for capturing and analysing the load/time signals generated during a drop tower impact event was developed and calibrated using static calibration techniques. The calibration factors for the four ranges available to this system are 624.86 kN/V, 318.00 kN/V, 117.01kN/V and 63.89 kN/V. The total impact energy of ASTM E604 specimens fabricated from CSA G40.21 350WT and tested at 1.5 m/s were within the scatter band of these previously characterized specimens.

7.0 REFERENCES

[1] KarisAllen, K.J., "DREP Instrumented Impact Testing System", DREP Technical Memorandum 89-23 July 1989.

[2] KarisAllen, K.J., Rhyno, K.J., and Matthews, J.R., "Calibration of the DREA Drop Weight Instrumented Impact Testing System", DREA RN/DL/85/1, January 1985.

Appendix A - File Structures

A.1 Variable File (*.var)

File Identification Code (variable file is 1001) <CR>
Name (text - max 100 characters) <CR>
Address (text - max 100 characters) <CR>
Phone No. (text - max 100 characters) <CR>
Test Date (text - max 100 characters) <CR>
Weight (float - kg) <CR>
Drop Height (float - m) <CR>
Tup ID (text - max 100 characters) <CR>
Anvil Span (float - mm) <CR>
Specimen ID (text - max 100 characters) <CR>
Material Spec (text - max 100 characters) <CR>
Specimen Height (float - mm) <CR>
Specimen Width (float - mm) <CR>
Specimen Length (float - mm) <CR>
Specimen Crack Length (float - mm) <CR>
Specimen Side Grooves (float - mm) <CR>
Temperature (text - max 100 characters) <CR>
Test Standard (text - max 100 characters) <CR>
Current File (text - max 100 characters) <CR>
Excitation/Gain (Integer - 1, 10, 100, 1000 - Excitation and gain set during calibration) <CR>
Calibration Factor (float - kN/volt) <CR>
Digitizing Rate (Integer - 1, 2, 5, 10, 20 - sweep time per point in microseconds) <CR>
Channel A Status (Integer - 0=OFF, 1=ON) <CR>
Channel B Status (Integer - 0=OFF, 1=ON) <CR>
Points in Trigger Delay (Integer - 0 to 2000) <CR>
Trigger Source (Integer - 0=Channel A, 1=Channel B) <CR>
Trigger Level (Integer - 0 to 255 represents -1.0V to 1.0V)<CR>
<EOF>

A.2 Load/Time File

File Identification Code (variable file is 1001) <CR>
Name (text - max 100 characters) <CR>
Address (text - max 100 characters) <CR>
Phone No. (text - max 100 characters) <CR>
Test Date (text - max 100 characters) <CR>
Weight (float - kg) <CR>
Drop Height (float - m) <CR>
Tup ID (text - max 100 characters) <CR>
Anvil Span (float - mm) <CR>
Specimen ID (text - max 100 characters) <CR>
Material Spec (text - max 100 characters) <CR>
Specimen Height (float - mm) <CR>
Specimen Width (float - mm) <CR>
Specimen Length (float - mm) <CR>
Specimen Crack Length (float - mm) <CR>
Specimen Side Grooves (float - mm) <CR>
Temperature (text - max 100 characters) <CR>
Test Standard (text - max 100 characters) <CR>
Current File (text - max 100 characters)<CR>
Excitation/Gain (Integer - 1, 10, 100, 1000 - Excitation and gain set during calibration) <CR>
Calibration Factor (float - kN/volt) <CR>
Digitizing Rate (Integer - 1, 2, 5, 10, 20 - sweep time per point in microseconds) <CR>
Channel A Status (Integer - 0=OFF, 1=ON) <CR>
Channel B Status (Integer - 0=OFF, 1=ON) <CR>
Points in Trigger Delay (Integer - 0 to 2000) <CR>
Trigger Source (Integer - 0=Channel A, 1=Channel B) <CR>
Trigger Level (Integer - 0 to 255 represents -1.0V to 1.0V) <CR>
No. of Data Points in File (Integer) <CR>
Start Data String (char - 0 to 255) .... End Data String (char - 0 to 255) <CR>
<EOF>

A.3 Load/Displacement File

File Name (File Name: Text) <CR>
Specimen ID (Specimen ID: text) <CR>
Total Energy (Total Energy: float - Joules) <CR>
Cursor Energy (Cursor Energy: float - Joules) <CR>
Start Selected Load/Displacement Data Interval (float - mm, float - kN) <CR>

.
.
.
.
.
.

End Selected Load/Displacement Data Interval (float - mm, float - kN) <CR>
<EOF>

Appendix B - Calibration Data
(TUP Calibration (DREA/DL) Serial No. 07148)

B.1 Range 5VDC-X10

Instron % FS (%)	Impact System (Volts)	Instron Force (kN)
0	-0.0029	0
10.8	0.0113	10.56845
19.3	0.0246	18.88621
29.8	0.0414	29.16109
40.4	0.0581	39.53382
50.4	0.0731	49.31942
60.5	0.0906	59.20288
70.4	0.1062	68.89062
79.9	0.1215	78.18694
70.8	0.108	69.28205
60.3	0.0913	59.00717
50.5	0.0766	49.41728
39.8	0.0598	38.94669
30	0.0446	29.3568
20.2	0.0289	19.76691
10	0.0136	9.7856
0	-0.0031	0

Regression Output:	
Constant	2.3348
Std Err of Y Est	0.838696
R Squared	0.998942
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	624.8626 kN/Volt
Std Err of Coef.	5.251049

B.2 Range 1VDC-X100

Instron % FS (%)	Impact System (Volts)	Instron Force (kN)
0	-0.0031	0
10	0.0235	9.7856
20	0.054	19.5712
30.1	0.0851	29.45466
39.9	0.1172	39.04454
50.2	0.1485	49.12371
59.9	0.1794	58.61574
70	0.211	68.4992
80.6	0.2421	78.87194
69.4	0.2101	67.91206
60.1	0.1831	58.81146
50.9	0.154	49.8087
40.1	0.1216	39.24026

Regression Output:	
Constant	1.349338
Std Err of Y Est	0.673723
R Squared	0.999311
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	318.0095 kN/Volt
Std Err of Coef.	2.155367

30.4	0.0913	29.74822
20.7	0.0616	20.25619
9.8	0.0274	9.589888
0	-0.0031	0

B.3 Range 2.7VDC-X100

Instron % FS (%)	Impact System (Volts)	Instron Force (kN)
0	-0.0031	0
10.2	0.0717	9.981312
19.7	0.1488	19.27763
29.7	0.2331	29.06323
39.9	0.3209	39.04454
60.4	0.4954	59.10502
70.2	0.5792	68.69491
80.1	0.664	78.38266
70	0.5802	68.4992
60.3	0.5012	59.00717
50.5	0.4213	49.41728
40	0.334	39.1424
30.4	0.2538	29.74822
20.8	0.1754	20.35405
10.1	0.0828	9.883456
0	-0.0022	0

Regression Output	
Constant	0.706496
Std Err of Y Est	0.698064
R Squared	0.9993
No. of Observations	16
Degrees of Freedom	14

X Coefficient(s) 117.0178 kN/Volt
Std Err of Coef. 0.82774

B.4 Range 5VDC-X100

Instron % FS (%)	Impact System (Volts)	Instron Force (kN)
0	-0.0031	0
5.1	0.0561	4.990656
10.1	0.1358	9.883456
15.4	0.2043	15.06982
19.7	0.2819	19.27763
25.3	0.3621	24.75757
30	0.437	29.3568
34.9	0.5193	34.15174
40	0.5996	39.1424
44.9	0.6749	43.93734
50.3	0.7611	49.22157

Regression Output	
Constant	0.806491
Std Err of Y Est	0.541864
R Squared	0.998775
No. of Observations	20
Degrees of Freedom	18

X Coefficient(s) 63.89549 kN/Volt
Std Err of Coef. 0.527481

45.1	0.6804	44.13306
40.2	0.6052	39.33811
34.7	0.5241	33.95603
30.2	0.4553	29.55251
24.8	0.373	24.26829
19.6	0.295	19.17978
14.6	0.2193	14.28698
9.5	0.14	9.29632
0	-0.002	0

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5. DATE OF PUBLICATION (Month and year of publication of document.) October 1997	6a. NO. OF PAGES (Total containing information. Include Annexes, Appendices, etc.) 22	6b. NO. OF REFS. (Total cited in document.) 2

6. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

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A system for capturing and analysing the load/time signals generated during a drop tower impact event has been developed and calibrated using static calibration techniques. The calibration factors for the four ranges available to this system were 624.86 kN/V, 318.00 kN/V, 117.01 kN/V and 63.89 kN/V. The total impact energy of ASTM E604 specimens fabricated from CSA G40.21 350 WT and tested at 1.5 m/s were within the scatter band of these previously charaterized specimens.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus. e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title).

drop tower
ASTM E604
DT
Dynamic Tear
instrumented impact testing

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