Crashworthiness Research of Prototype Hydrogen Fuel Cell Vehicles: Task Order 7 Project Report

Appendix C
Electrical Isolation Log Sheets
DISCLAIMER

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Data Sheet No. 1
Pre-Impact Electrical Isolation Measurements & Calculations

Vehicle: Rear Crash  NHTSA No.: 

A. PREPARATION
Safety Analyzer Power-Up Time (Step 1): 9:56 AM
Ambient Temperature (Step 4): (68°F) 20 °C
Comments: UNPLUGGED SAFETY ANALYZER FOR ~20 SECONDS TO SWITCH OUTLETS.
PRE-IMPACT MEASUREMENTS PERFORMED INDOORS, TEMPERATURE READ FROM THERMOSTAT.
Completed by: REK
Recorded by: SMG

B. BATTERY ISOLATION
Voltage Measured Across (Step 6):
DC-1 and DC-2: 0.002 Vdc
DC-1 and TPGND: 0.073 Vdc
DC-2 and TPGND: 0.077 Vdc
Electrical Isolation Between DC-1 and Electrical Chassis (Step 10):
Leakage Current: 0.34 mA
Test Voltage Reading: 160 Vdc
Electrical Isolation (I/Leakage Current): 2900 ohms/volt
Electrical Isolation Between DC-2 and Electrical Chassis (Step 12):
Leakage Current: 0.36 mA
Test Voltage Reading: 159 Vdc
Electrical Isolation (I/Leakage Current): 2800 ohms/volt
Comments: AFTER BATTERY ISOLATION TESTING, UNPLUGGED SAFETY ANALYZER TO SWITCH OUTLETS.
Completed by: REK
Recorded by: SMG

C. FUEL CELL ISOLATION
Voltage Measured Across (Step 14):
DC-5 and DC-6: 0.000 Vdc
DC-5 and TPGND: 0.009 Vdc
DC-6 and TPGND: 0.009 Vdc
Electrical Isolation Between DC-5 and Electrical Chassis (Step 17):
Leakage Current: 5.71 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (I/Leakage Current): 175 ohms/volt
Electrical Isolation Between DC-6 and Electrical Chassis (Step 19):
Leakage Current: 5.72 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (I/Leakage Current): 175 ohms/volt
Comments: 
Completed by: REK
Recorded by: SMG
D. MOTOR CONTROL UNIT DC ISOLATION

Voltage Measured Across (Step 20):
DC-3 and DC-4: 0.006 Vdc
DC-3 and TPGND: 0.069 Vdc
DC-4 and TPGND: 0.053 Vdc

Electrical Isolation Between DC-3 and Electrical Chassis (Step 22):
Leakage Current: 1.12 mA
Test Voltage Reading: 481 Vdc
Electrical Isolation (1/Leakage Current): 893 ohms/volt

Electrical Isolation Between DC-4 and Electrical Chassis (Step 24):
Leakage Current: 1.12 mA
Test Voltage Reading: 481 Vdc
Electrical Isolation (1/Leakage Current): 893 ohms/volt

Comments: Voltages measured in Step 20 began at recorded value and continued to fall. Complete by: REK
Recorded by: SMG

E. MOTOR CONTROL UNIT AC ISOLATION

Voltage Measured Across (Step 25):
AC-1 and AC-2: 0.000 Vdc
AC-1 and AC-3: 0.000 Vdc
AC-2 and AC-3: 0.000 Vdc
AC-1 and TPGND: 0.098 Vdc
AC-2 and TPGND: 0.098 Vdc
AC-3 and TPGND: 0.097 Vdc

Electrical Isolation Between AC-1 and Electrical Chassis (Step 27):
Leakage Current: 1.12 mA
Test Voltage Reading: 481 Vdc
Electrical Isolation (1/Leakage Current): 893 ohms/volt

Electrical Isolation Between AC-2 and Electrical Chassis (Step 29):
Leakage Current: 1.12 mA
Test Voltage Reading: 481 Vdc
Electrical Isolation (1/Leakage Current): 893 ohms/volt

Electrical Isolation Between AC-3 and Electrical Chassis (Step 31):
Leakage Current: 1.12 mA
Test Voltage Reading: 481 Vdc
Electrical Isolation (1/Leakage Current): 893 ohms/volt

Comments: Complete by: REK
Recorded by: SMG

Additional Comments: Complete at 10:47 AM

RECORDED BY: Scott Gilmore DATE: 4-3-2012
APPROVED BY: DATE: 4-3-2012
Data Sheet No. 2
Post-Impact Electrical Isolation Measurements and Calculations

Vehicle: ______________________  NHTSA No.: ______________________

A. PREPARATION
   Safety Analyzer Power-Up Time (Step 1): 3:59 pm
   Ambient Temperature (Step 4): 13.5°C
   Comments: SWITCHED OUTLETS AT 4:41 PM
   Rear Crash  Completed by: REK
   Recorded by: S.M.G.

B. BATTERY ISOLATION
   Voltage Measured Across (Step 6):
   DC-1 and DC-2: 0.070 Vdc
   DC-1 and TPGND: 0.013 Vdc
   DC-2 and TPGND: 0.006 Vdc
   Electrical Isolation Between DC-1 and Electrical Chassis (Step 10):
   Leakage Current: 0.36 mA
   Test Voltage Reading: 162 Vdc
   Electrical Isolation (I/Leakage Current): 2800 ohms/volt
   Electrical Isolation Between DC-2 and Electrical Chassis (Step 12):
   Leakage Current: 0.36 mA
   Test Voltage Reading: 160 Vdc
   Electrical Isolation (I/Leakage Current): 2800 ohms/volt
   Comments: ______________________
   Completed by: REK
   Recorded by: S.M.G.

C. FUEL CELL ISOLATION
   Voltage Measured Across (Step 14):
   DC-5 and DC-6: 5.000 Vdc
   DC-5 and TPGND: 5.002 Vdc
   DC-6 and TPGND: 5.002 Vdc
   Electrical Isolation Between DC-5 and Electrical Chassis (Step 17):
   Leakage Current: 5.61 mA
   Test Voltage Reading: 479 Vdc
   Electrical Isolation (I/Leakage Current): 178 ohms/volt
   Electrical Isolation Between DC-6 and Electrical Chassis (Step 19):
   Leakage Current: 5.61 mA
   Test Voltage Reading: 479 Vdc
   Electrical Isolation (I/Leakage Current): 178 ohms/volt
   Comments: ______________________
   Completed by: REK
   Recorded by: S.M.G.
D. MOTOR CONTROL UNIT DC ISOLATION
Voltage Measured Across (Step 20):
DC-3 and DC-4: .027 \downarrow Vdc
DC-3 and TPGND: .191 \downarrow Vdc
DC-4 and TPGND: .141 \downarrow Vdc
Electrical Isolation Between DC-3 and Electrical Chassis (Step 22):
Leakage Current: 1.12 mA
Test Voltage Reading: 481 Vdc
Electrical Isolation (1/Leakage Current): 893 ohms/volt
Electrical Isolation Between DC-4 and Electrical Chassis (Step 24):
Leakage Current: 1.12 mA
Test Voltage Reading: 477 Vdc
Electrical Isolation (1/Leakage Current): 893 ohms/volt
Comments: VOLTAGES MEASURED IN STEP 20 BEGAN AT RECORDED VALUE AND CONTINUED TO FALL "\downarrow"
Completed by: REK
Recorded by: S.M.G.

E. MOTOR CONTROL UNIT AC ISOLATION
Voltage Measured Across (Step 25):
AC-1 and AC-2: 0.000 Vdc
AC-1 and AC-3: 0.000 Vdc
AC-2 and AC-3: 0.000 Vdc
AC-1 and TPGND: 0.013 \downarrow Vdc
AC-2 and TPGND: 0.012 \uparrow Vdc
AC-3 and TPGND: 0.026 \uparrow Vdc
Electrical Isolation Between AC-1 and Electrical Chassis (Step 27):
Leakage Current: 1.12 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (1/Leakage Current): 893 ohms/volt
Electrical Isolation Between AC-2 and Electrical Chassis (Step 29):
Leakage Current: 1.12 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (1/Leakage Current): 893 ohms/volt
Electrical Isolation Between AC-3 and Electrical Chassis (Step 31):
Leakage Current: 1.12 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (1/Leakage Current): 893 ohms/volt
Comments: VOLTAGES MEASURED IN STEP 25 BEGAN AT RECORDED VALUE AND CONTINUED TO FALL "\downarrow" OR RISE "\uparrow"
Completed by: REK
Recorded by: S.M.G.

Additional Comments: COMPLETE AT 5:11 PM

RECORDED BY: Scott Gillen DATE: 4-11-2012
APPROVED BY: \underline{Jim Mironov} DATE: 4-11-2012
Data Sheet No. 1
Pre-Impact Electrical Isolation Measurements & Calculations

Vehicle: Side Crash  NHTSA No.: ______________________

A. PREPARATION
Safety Analyzer Power-Up Time (Step 1): 8:56 AM
Ambient Temperature (Step 4): 68°F  20 °C
Comments: PRE-IMPACT MEASUREMENTS PERFORMED INDOORS, TEMPERATURE READ FROM THERMOMETER.  
Completed by: TMEK  
Recorded by: SMG

B. BATTERY ISOLATION
Voltage Measured Across (Step 6):
DC-1 and DC-2: 0.000 Vdc
DC-1 and TPGND: 0.002 Vdc
DC-2 and TPGND: 0.002 Vdc

Electrical Isolation Between DC-1 and Electrical Chassis (Step 10):
Leakage Current: 0.34 mA
Test Voltage Reading: 160 Vdc
Electrical Isolation (1/Leakage Current): 2900 ohms/volt

Electrical Isolation Between DC-2 and Electrical Chassis (Step 12):
Leakage Current: 0.36 mA
Test Voltage Reading: 160 Vdc
Electrical Isolation (1/Leakage Current): 2800 ohms/volt

Comments:
Completed by: TMEK  
Recorded by: SMG

C. FUEL CELL ISOLATION
Voltage Measured Across (Step 14):
DC-5 and DC-6: 0.000 Vdc
DC-5 and TPGND: 0.002 Vdc
DC-6 and TPGND: 0.002 Vdc

Electrical Isolation Between DC-5 and Electrical Chassis (Step 17):
Leakage Current: 5.63 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (1/Leakage Current): 178 ohms/volt

Electrical Isolation Between DC-6 and Electrical Chassis (Step 19):
Leakage Current: 5.63 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (1/Leakage Current): 178 ohms/volt

Comments:
Completed by: TMEK  
Recorded by: SMG
D. MOTOR CONTROL UNIT DC ISOLATION

Voltage Measured Across (Step 20):

Side Crash: $0.01 \downarrow \text{Vdc}$
DC-3 and TPGND: $0.160 \downarrow \text{Vdc}$
DC-4 and TPGND: $0.100 \downarrow \text{Vdc}$

Electrical Isolation Between DC-3 and Electrical Chassis (Step 22):

Leakage Current: $1.15 \text{mA}$
Test Voltage Reading: $471 \text{Vdc}$
Electrical Isolation (1/Leakage Current): $885 \text{ohms/volt}$

Electrical Isolation Between DC-4 and Electrical Chassis (Step 24):

Leakage Current: $1.15 \text{mA}$
Test Voltage Reading: $479 \text{Vdc}$
Electrical Isolation (1/Leakage Current): $870 \text{ohms/volt}$

Comments: Voltages measured in step 20 began at recorded value and continued to fall. Completed by: REK
Recorded by: SMG

E. MOTOR CONTROL UNIT AC ISOLATION

Voltage Measured Across (Step 25):

AC-1 and AC-2: $0.000 \text{Vdc}$
AC-1 and AC-3: $0.000 \text{Vdc}$
AC-2 and AC-3: $0.000 \text{Vdc}$
AC-1 and TPGND: $0.025 \text{Vdc}$
AC-2 and TPGND: $0.035 \text{Vdc}$
AC-3 and TPGND: $0.032 \text{Vdc}$

Electrical Isolation Between AC-1 and Electrical Chassis (Step 27):

Leakage Current: $1.13 \text{mA}$
Test Voltage Reading: $481 \text{Vdc}$
Electrical Isolation (1/Leakage Current): $885 \text{ohms/volt}$

Electrical Isolation Between AC-2 and Electrical Chassis (Step 29):

Leakage Current: $1.13 \text{mA}$
Test Voltage Reading: $481 \text{Vdc}$
Electrical Isolation (1/Leakage Current): $885 \text{ohms/volt}$

Electrical Isolation Between AC-3 and Electrical Chassis (Step 31):

Leakage Current: $1.13 \text{mA}$
Test Voltage Reading: $481 \text{Vdc}$
Electrical Isolation (1/Leakage Current): $885 \text{ohms/volt}$

Comments: Complete at 9:50 AM
Completed by: REK
Recorded by: SMG

Additional Comments: COMPLETE AT 9:50 AM

RECORDED BY: Scott Illman DATE: 4-3-2012
APPROVED BY: Edward J. Sullivan DATE: 4-3-2012
Data Sheet No. 2
Post-Impact Electrical Isolation Measurements and Calculations

Vehicle: ___________________ NHTSA No.: ___________________

Side Crash

A. PREPARATION
Safety Analyzer Power-Up Time (Step 1): 3:00 PM
Ambient Temperature (Step 4): 14.4°C
Comments: 5 SECOND OUTLET SWITCH AT 3:57 PM ON AT 4:00 PM
Completed by: ___________
Recorded by: ___________

B. BATTERY ISOLATION
Voltage Measured Across (Step 6):
DC-1 and DC-2: 0.802 Vdc
DC-1 and TPGND: 0.000 Vdc
DC-2 and TPGND: 0.000 Vdc
Electrical Isolation Between DC-1 and Electrical Chassis (Step 10):
Leakage Current: 0.37 mA
Test Voltage Reading: 160 Vdc
Electrical Isolation (1/Leakage Current): 2700 ohms/volt
Electrical Isolation Between DC-2 and Electrical Chassis (Step 12):
Leakage Current: 0.37 mA
Test Voltage Reading: 159 Vdc
Electrical Isolation (1/Leakage Current): 2700 ohms/volt
Comments: VOLTAGE MEASURED AT STEP 6 BEGAN AT RECORDED VALUE
AND CONTINUED TO FALL. “↓”
Completed by: ___________
Recorded by: ___________

C. FUEL CELL ISOLATION
Voltage Measured Across (Step 14):
DC-5 and DC-6: 0.000 Vdc
DC-5 and TPGND: 0.003 Vdc
DC-6 and TPGND: 0.003 Vdc
Electrical Isolation Between DC-5 and Electrical Chassis (Step 17):
Leakage Current: 5.66 mA
Test Voltage Reading: 481 Vdc
Electrical Isolation (1/Leakage Current): 177 ohms/volt
Electrical Isolation Between DC-6 and Electrical Chassis (Step 19):
Leakage Current: 5.66 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (1/Leakage Current): 177 ohms/volt
Comments: 
Completed by: ___________
Recorded by: ___________
D. MOTOR CONTROL UNIT DC ISOLATION
Voltage Measured Across (Step 20):
DC-3 and DC-4: 0.121 Vdc
DC-3 and TPGND: 0.506 Vdc
DC-4 and TPGND: 0.345 Vdc

Electrical Isolation Between DC-3 and Electrical Chassis (Step 22):
Leakage Current: 1.13 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (1/Leakage Current): 885 ohms/volt

Electrical Isolation Between DC-4 and Electrical Chassis (Step 24):
Leakage Current: 1.13 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (1/Leakage Current): 885 ohms/volt

Comments: Voltages measured in step 20 began at recorded values
and continued to fall. 
Completed by: TCEK
Recorded by: S.M.G.

E. MOTOR CONTROL UNIT AC ISOLATION
Voltage Measured Across (Step 25):
AC-1 and AC-2: 0.006 Vdc
AC-1 and AC-3: 0.000 Vdc
AC-2 and AC-3: 0.000 Vdc
AC-1 and TPGND: 0.073 Vdc
AC-2 and TPGND: 0.055 Vdc
AC-3 and TPGND: 0.053 Vdc

Electrical Isolation Between AC-1 and Electrical Chassis (Step 27):
Leakage Current: 1.13 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (1/Leakage Current): 885 ohms/volt

Electrical Isolation Between AC-2 and Electrical Chassis (Step 29):
Leakage Current: 1.13 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (1/Leakage Current): 885 ohms/volt

Electrical Isolation Between AC-3 and Electrical Chassis (Step 31):
Leakage Current: 1.13 mA
Test Voltage Reading: 479 Vdc
Electrical Isolation (1/Leakage Current): 885 ohms/volt

Comments: Voltages measured in step 25 began at recorded values
and continued to fall.
Completed by: TCEK
Recorded by: S.M.G.

Additional Comments: Complete at 4:23 PM.

RECORDED BY: Scott Hilleman DATE: 4-14-2012
APPROVED BY: Edward J. Gehrke DATE: 4-14-2012