

June 12, 2013

Strongwell - Chatfield Division

ASTM D790 Flexural, D2344Short Beam Shear, D695Compression, and D256 Notched IZOD;

Tested at Room Temperature and ~-160°C

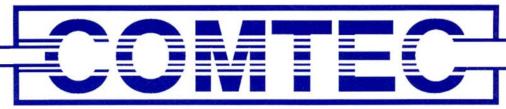
COMTEC Job# 050113-01

Composite Materials Technology Center 175 W Mark St. Stark Hall 203 Winona State University Winona, MN 55987

Steven Terfehr Sr. COMTEC Engineering Intern

Matt Benson

Director of COMTEC



Sample Information

Received:

- QTY 25 Flex D790 Specimens
- QTY 25 Short Beam Shear D2344 Specimens
- QTY 25 Compression D695 Specimens
- QTY 25 IZOD D256 Specimens

Test Coupon Preparation:

• Customer Prepared

Testing Parameters

Instrument(s): Instron Series 3369 and Wiedemann Baldwin Impact testers

Test Method: Flex (D790), Short Beam Shear (D2344), Compression (D695), and IZOD (D256)

Test Operators: David Kujak, Tyler Phelps, Steven Terfehr

Test Date: 05/30/2013 – 06/07/13

Test Conditions: RT and depressed temp of at least -160C

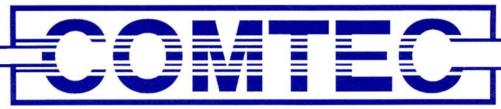
Test Temperature: 72.1°F Test Humidity: 55% RH

Testing Capacity:

Instron Series 3369: D790 and D2344 – 2000 lb; D695 – 10,000 Baldwin Impact Tester, Serial 1099; Dial Display: 16 ft./lbs. (8x)

Calibration: Both were verified on 09/17/12 (due 9/30/13) per ASTM E 23-07 Annex A2 by

Instron Corp.



Testing Procedure

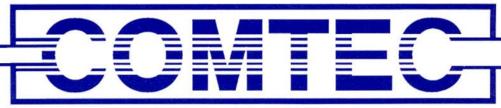
Flex (D790), Short Beam Shear (D2344), Compression (D695), and IZOD (D256) specimens were tested at room temperature (~21°C) and depressed temperature (~-160°C)

Room Temperature Testing Procedure:

• Standard ASTM protocols were used on all of the room temperature testing.

Depressed (Cryo) Temperature Testing Procedure:

- Standard ASTM protocols were used on all of the depressed temperature testing.
- Strongwell requested the depressed temperature testing be performed at least -160 °C. Strongwell's customer was interested in failure potential if their grating was exposed to a Liquefied natural gas spill.
 - Liquefied natural gas (LNG) is natural gas in its liquid form, it condenses at -161°
 Celsius (-259° F).
- COMTEC performed the following conditioning procedure on all four of the depressed temperature tests:
 - o Specimens were submerged in a Liquid Nitrogen (LN2) bath for 1 hour prior to measurement.
 - Specimens were measured and recorded (thickness and width) then placed back into LN2 for an hour.
 - o Specimens were removed from the bath one by one and immediately placed in the appropriate test fixture.
 - o The samples where then tested one at a time after they had been taken directly from the LN2 bath.



Testing Results

• See attached Instron generated test reports (QTY 8 total)

Summary Table of Testing Results:

Test Method	Property	Temp	Results (Average)
Compression	Compressive Stress at Yield (Ksi)	21°C	54.6
ASTM D695		-160°C	55.3
Flex	Flexural Stress at Max Load (Ksi)	21°C	91.2
ASTM D790		-160°C	95.6
Short Beam Shear	Short Beam Shear Strength (Psi)	21°C	4977.8
ASTM D2344		-160°C	5834.1
Izod	Impact Strength (ft*lb/in)	21°C	67.2
ASTM D256		-160°C	72