# Cost-effective Rollover Protective Structure (CROPS)

for Wheeled Agricultural Tractors

Massey Ferguson 135 SERIES

TESTING INFORMATION

This testing report was updated in March 2021.

This report provides enhanced information on the testing procedures and data collected by NIOSH. Specific report updates include tractor chassis information, static testing information and the reasoning for the testing.

Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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Static testing of a fully assembled NIOSH CROPS was performed at the NIOSH Division of Safety Research laboratories in Morgantown, West Virginia, and in accordance with testing criteria outlined in SAE J2194. The main purpose of the static laboratory testing was to simulate field upset in a controlled and repeatable environment (SAE J2194). The static loading sequence consisted of four tests: (1) longitudinal loading, (2) 1st vertical crush loading, (3) transverse loading, and (4) 2nd vertical crush loading. During any of the four phases of static testing, the CROPS cannot be altered (e.g., bolts tightened, material repairs) and cannot touch or enter the operator clearance zone.

During the static laboratory testing, the loads were applied slowly over time, with the applied force and corresponding displacement collected. From these measurements, the energy absorbed by the CROPS was calculated (see graphs).

The photos show the condition of the tested CROPS at the beginning and the end of each of the four static tests.

## General Testing Information

| | |
|---|---|
| **Date(s):** | CROPS Testing - 10/06/2008,10/07/2008, 10/09/2008 |
| **Laboratory:** | NIOSH High Bay Lab |
| | 1095 Willowdale Rd |
| | Morgantown, WV 26505 |
| **Conducted** by: | Division of Safety Research/Protective Technology Branch |
| | Engineering Staff |
| **Machine manufacturer:** | Massey Ferguson |
| **ROPS manufacturer:** | NIOSH |
| | 1095 Willowdale Rd |
| | Morgantown, WV 26505 |

## Testing Background

An energy absorbing CROPS test was conducted between 09/06/2008 and 09/09/2008 following the industry standard that was current in 2008, SAE J2194. This test was a retest of the CROPS design with the main difference of reducing the base plates from ¾ in thickness to ½ in thickness. This change was performed to make the CROPS more manufacturable.

## Specification of the Test Machine

**Chassis:** Massey Ferguson 135

**Reference Mass (mt):** 6000 lbs.

## Specification of the CROPS

**CROPS Identification:** CROPS with ½ inch base plates

**ROPS Design/Test Type:** Energy-Absorbing

**Required Energy Absorption:**

| | | |
|---|---|---|
| **Longitudinal Loading:** | **$E_{il.1}$ = (1.4) mt** | 33723 in-lbs. |
| **Side Loading:** | **$E_{is}$ = (1.75) mt** | 42153 in-lbs. |
| **Vertical Crush Loading:** | **$F_R$ = (20) mt** | 12236 lbs. |

**Extension to Other Machines:** MF 130, MF 150, MF 230, MF 235, MF 240, MF 245

## Test Equipment

**Description of the load application devices:**
The horizontal loads were applied by means of a hydraulic cylinder. The flow rate to the hydraulic cylinder was controlled to maintain the static nature of the test, as described in SAE J2194. The vertical crush load was applied with two hydraulic cylinders mounted on each end of a steel I-beam that was installed across the top of the CROPS.

**Description of the laboratory instrumentation:**

The instrumentation used for this test was:

- A 20,000 lb. load cell attached to the end of a hydraulic cylinder, which was used to measure the force being applied to the CROPS for the longitudinal and transverse testing.
- Two 20,000 lb. load cells attached to the ends of separate hydraulic cylinders, which were used to measure the applied crushing loads in the vertical testing.
- An LVDT (linear variable differential transducer), which was used to measure displacement of the CROPS throughout the testing.
- An MTS 458.20 MicroConsole, which controlled the applied forces.

Data Collection and Computation

- The test LVDT measurements and energy calculation of the testing were performed by a LabView program. The Simpson rule for integration was used to calculate the energy for the testing and outputted the data to a CSV file for analysis.
- The permanent deflection distance data was recorded by hand.

CROPS test temperature and description of how CROPS temperature/material options were met, the language below is taken from the SAE J2194 Standard, ROPS in this section is used synonymously with CROPS**:**

All material used for the ROPS met the requirements of SAE J2194 6.9 Material Requirements. The ROPS tests were performed at ambient temperature.

- All fasteners used to attach the ROPS to the tractor frame and to connect structural parts of the ROPS were SAE grade 5 through 8 or equivalent.
- All steel material used in the ROPS met the minimum Charpy V-notch impact energy requirements specified.
- All welding electrodes used in fabrication of structural members and mounts were compatible with the ROPS material.

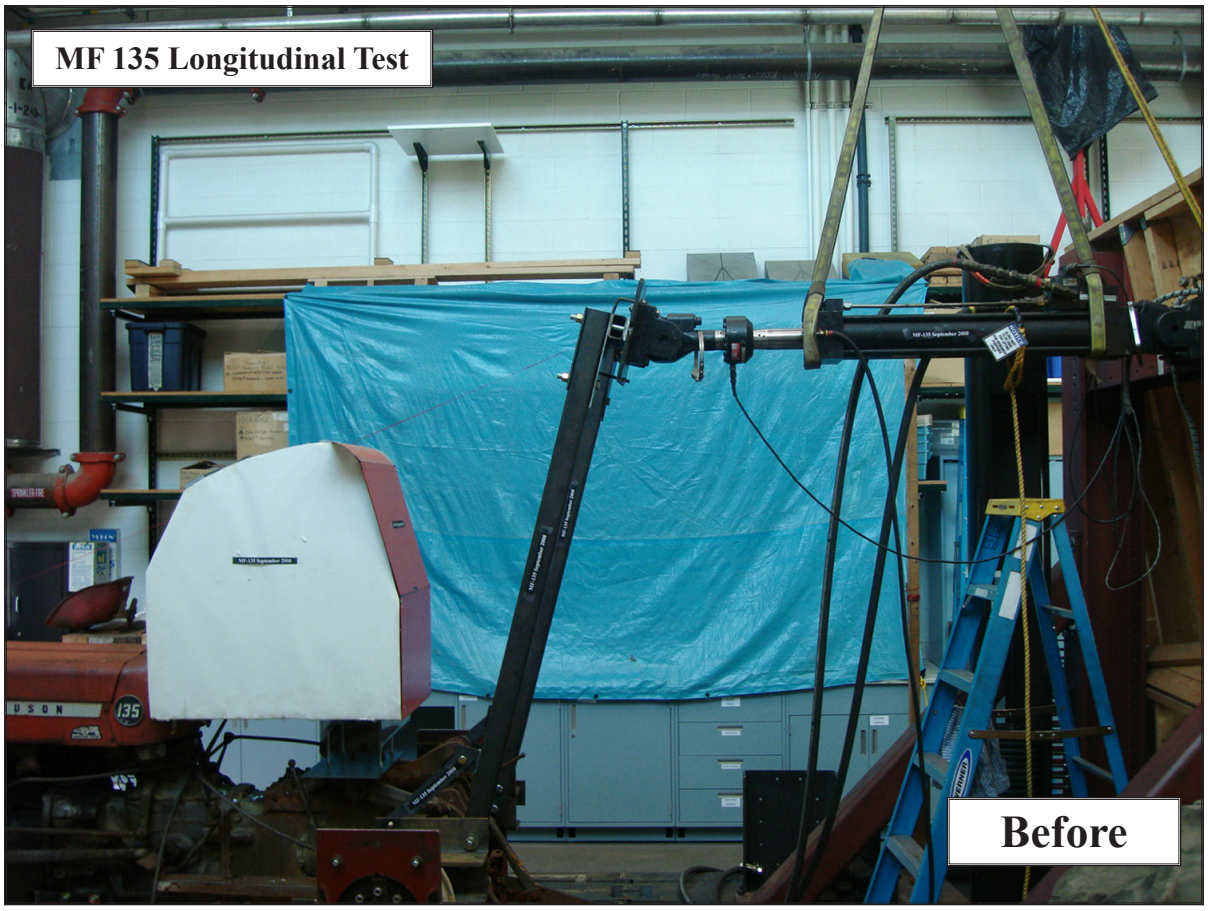
## Test Load Sequence

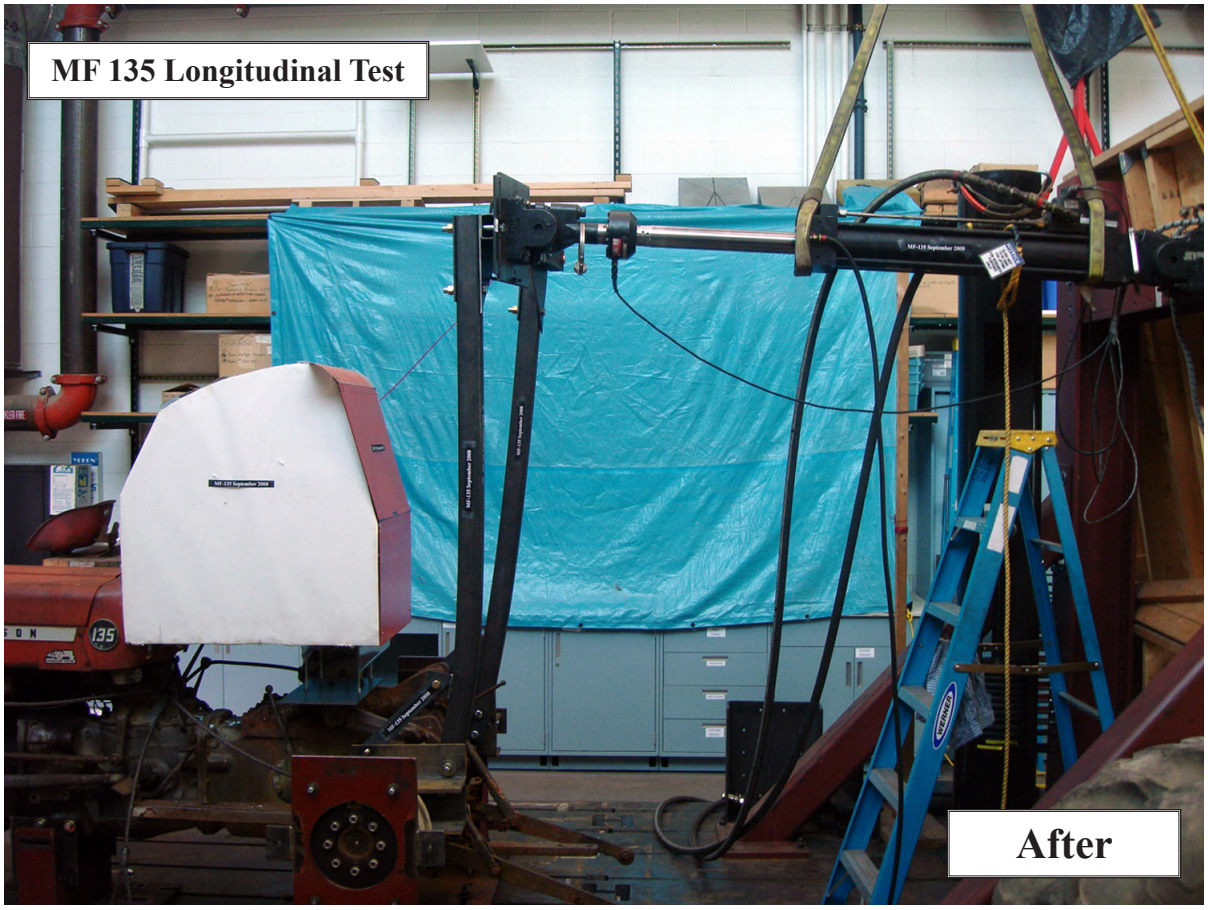
1. Longitudinal loading from the rear (left side of machine)
2. Vertical crush load
3. Transverse loading from the side (right side of machine)
4. Vertical crush load

## Test Setup

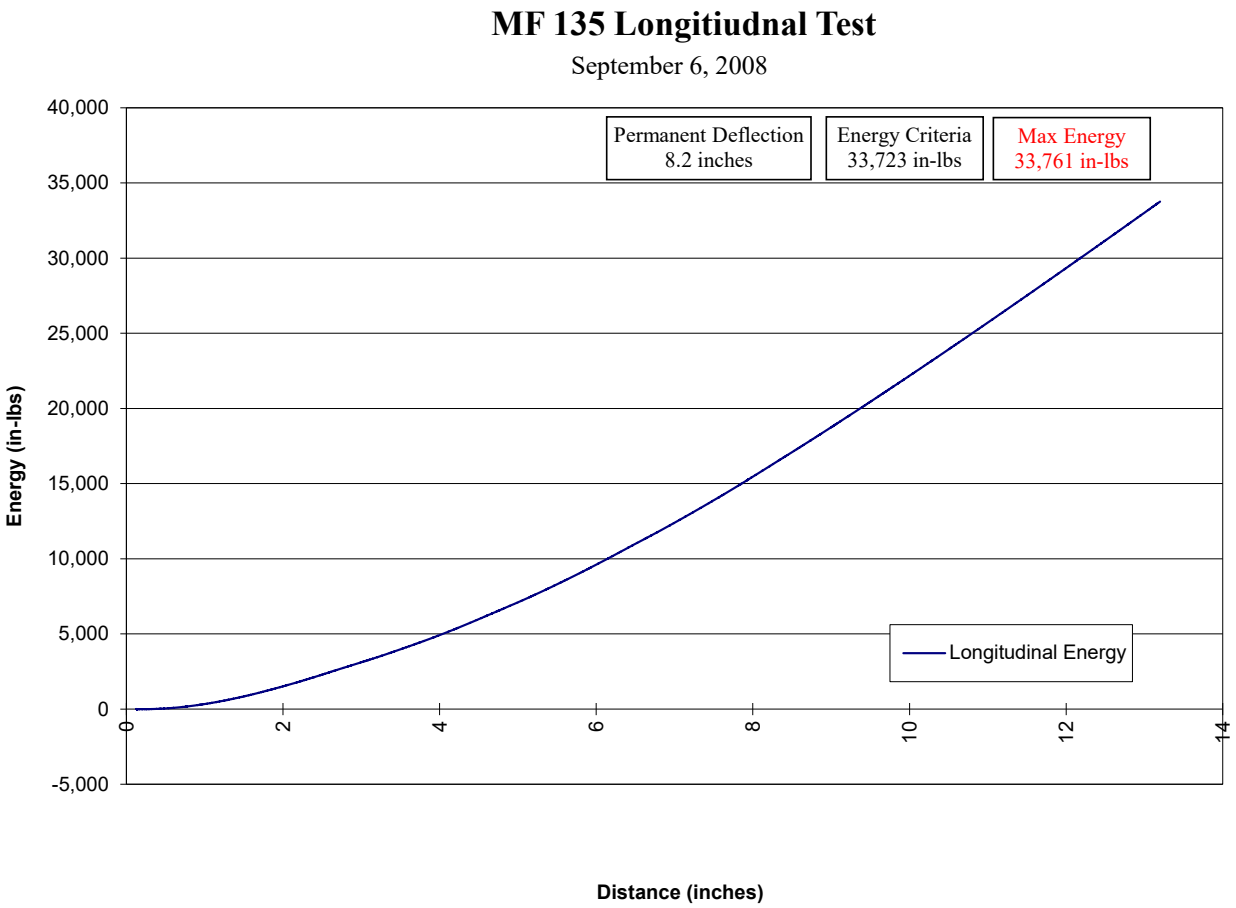
The tractor was bolted to a 20,000-pound test bed via custom manufactured mounting structures to simulate the tractor wheel height and to keep the tractor from moving during the test procedure.

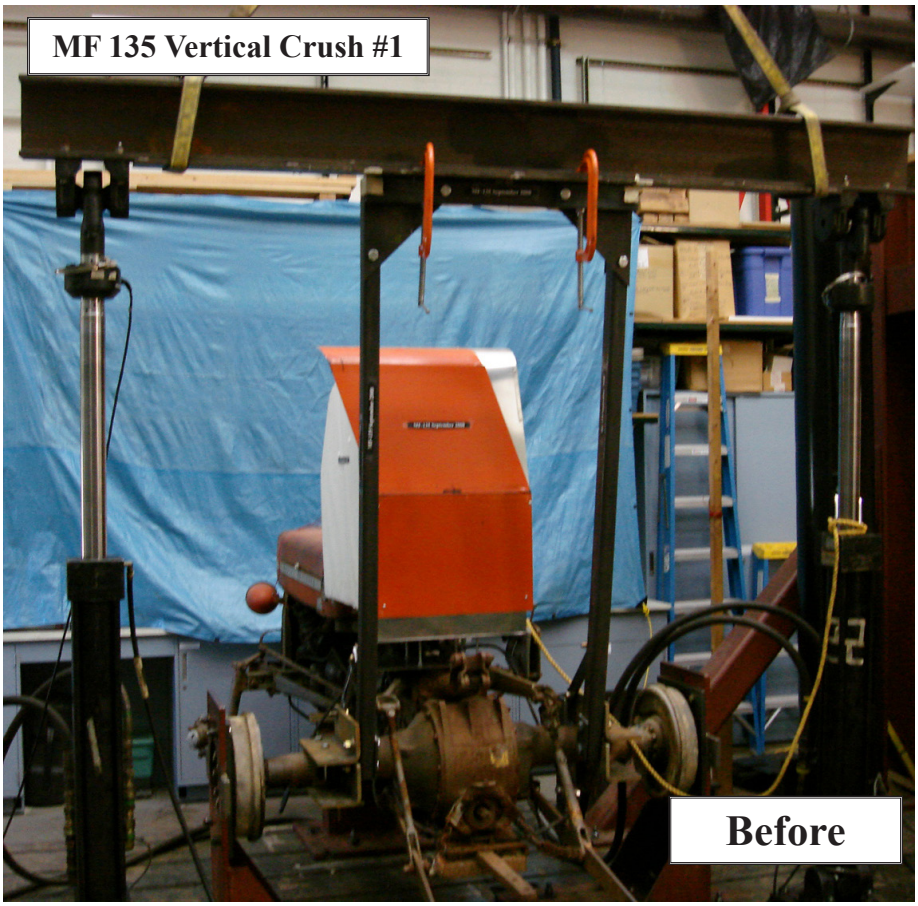
Between the testing sequence, the tractor was rotated such that the hydraulic cylinder could be positioned in the appropriate location for each of the 4 tests. This test set up is shown in the testing sequence pictures that follow.


MF 135 Longitudinal Test
Before


MF 135 Longitudinal Test
After

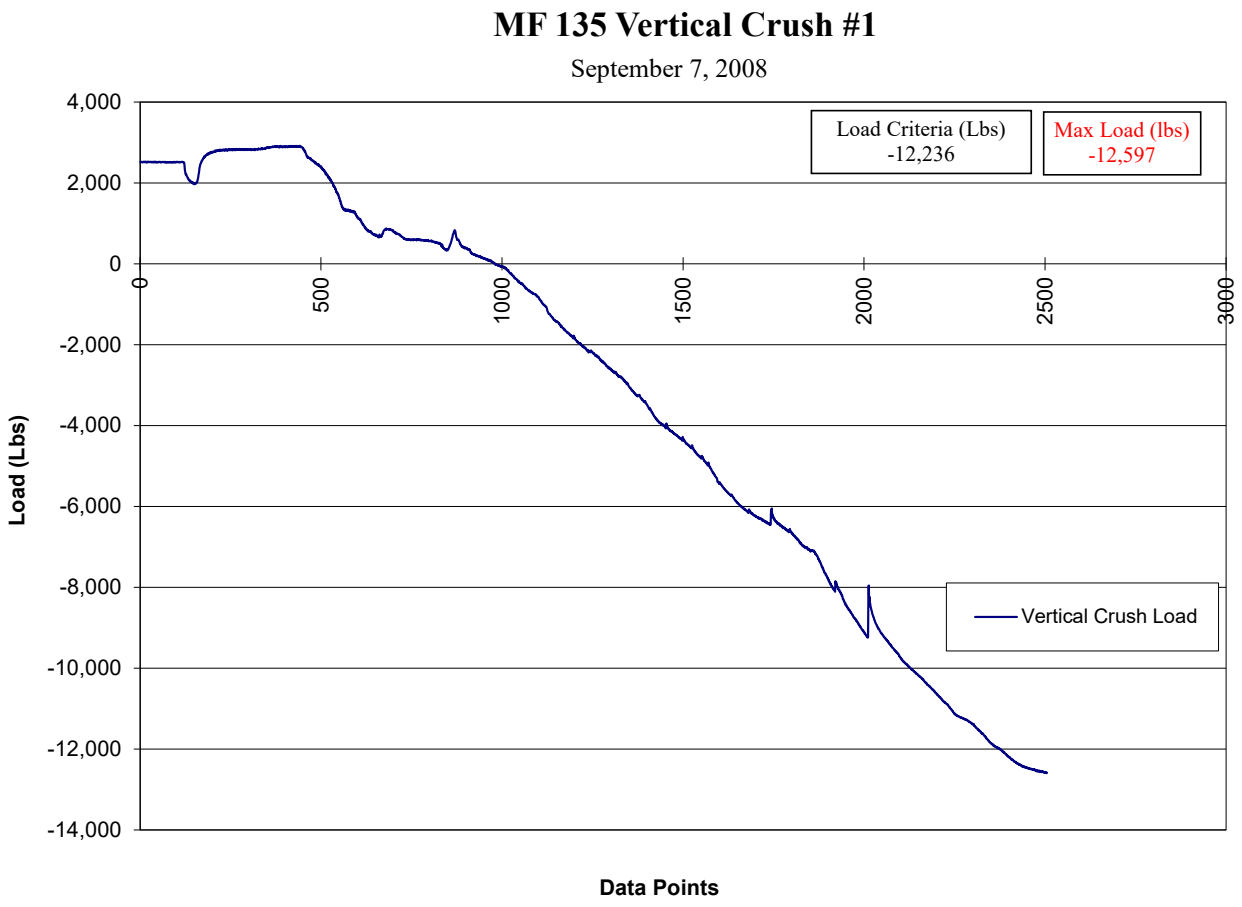
CROPS Lab Testing September 2008 MF 135 Series

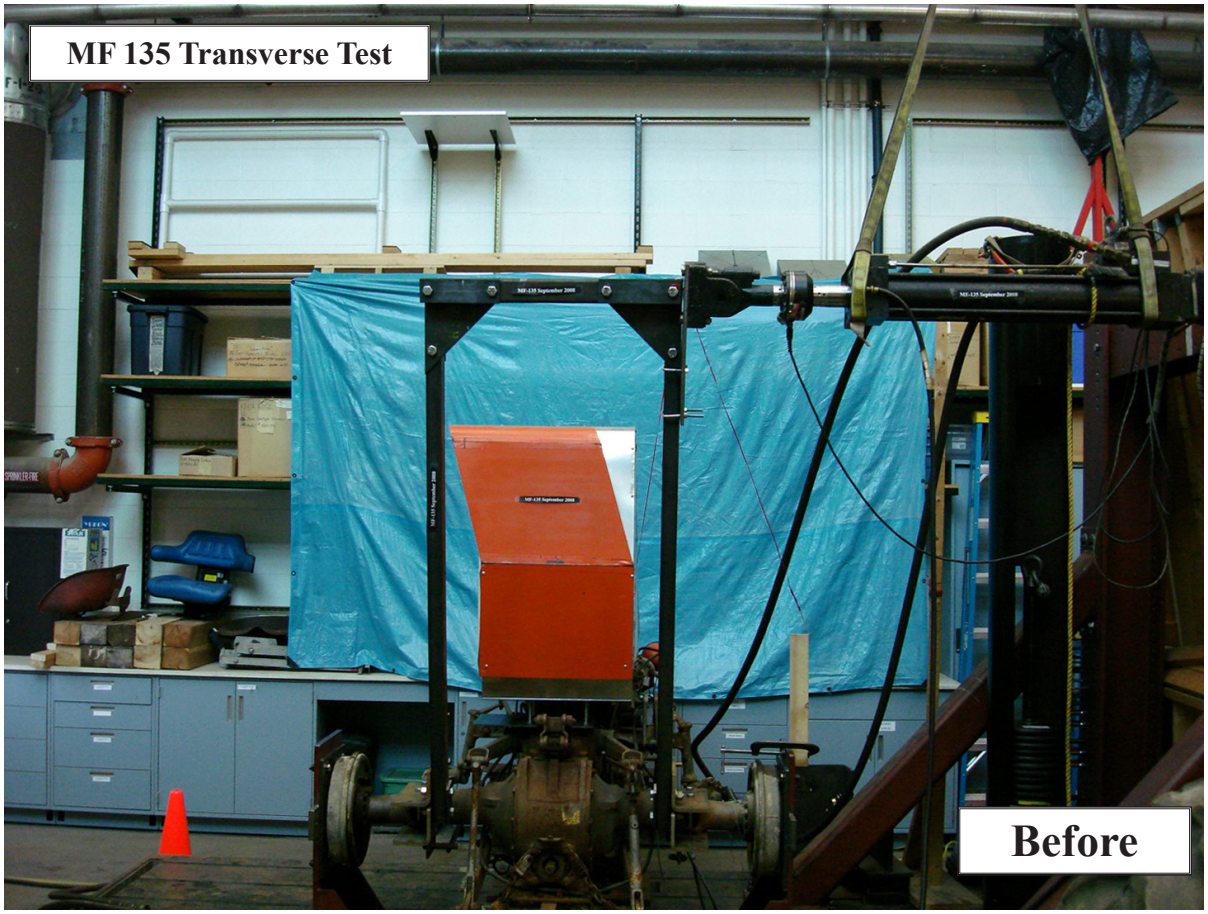


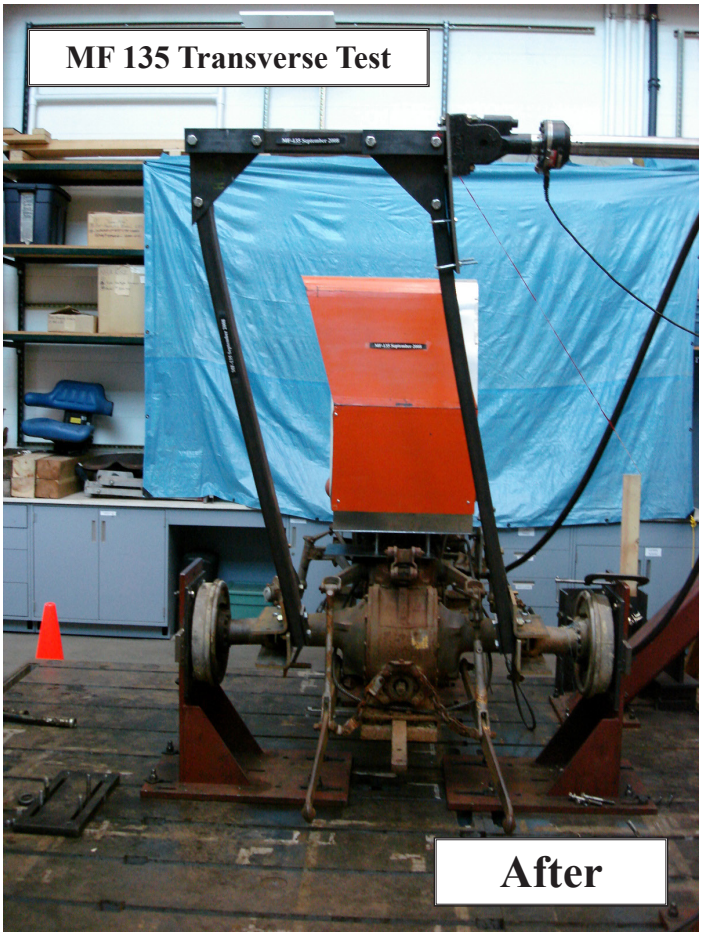

MF 135 Vertical Crush #1
Before


MF 135 Vertical Crush #1
After

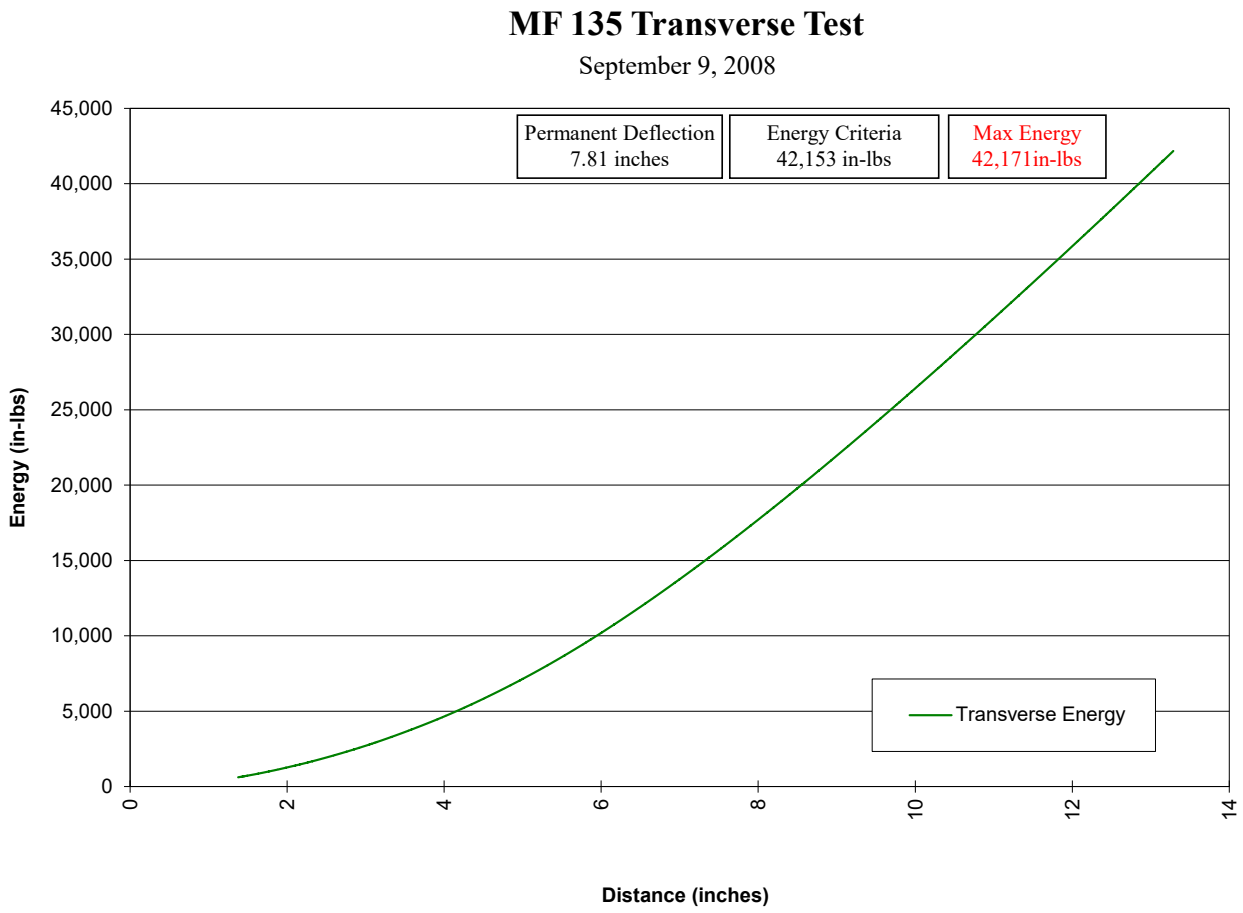
CROPS Lab Testing September 2008 MF 135 Series

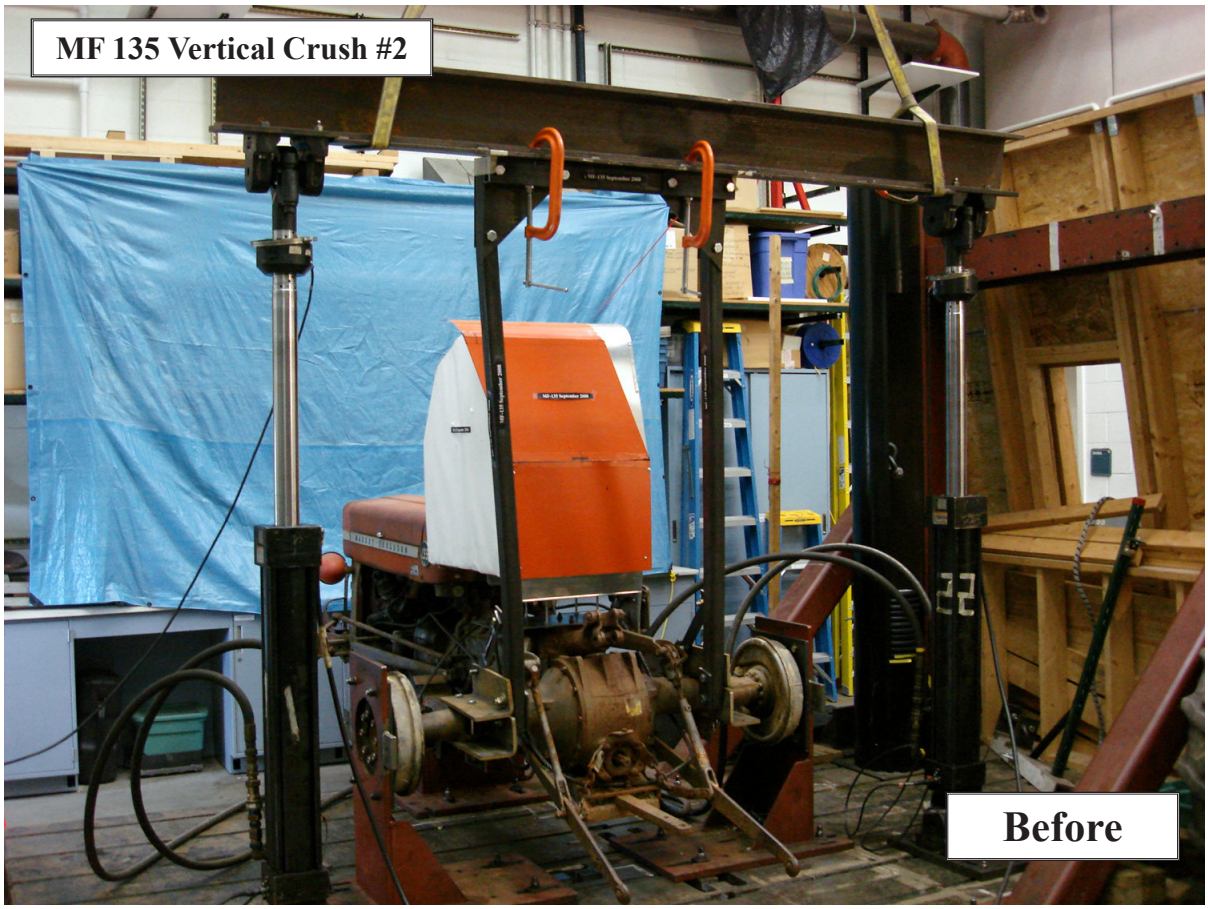


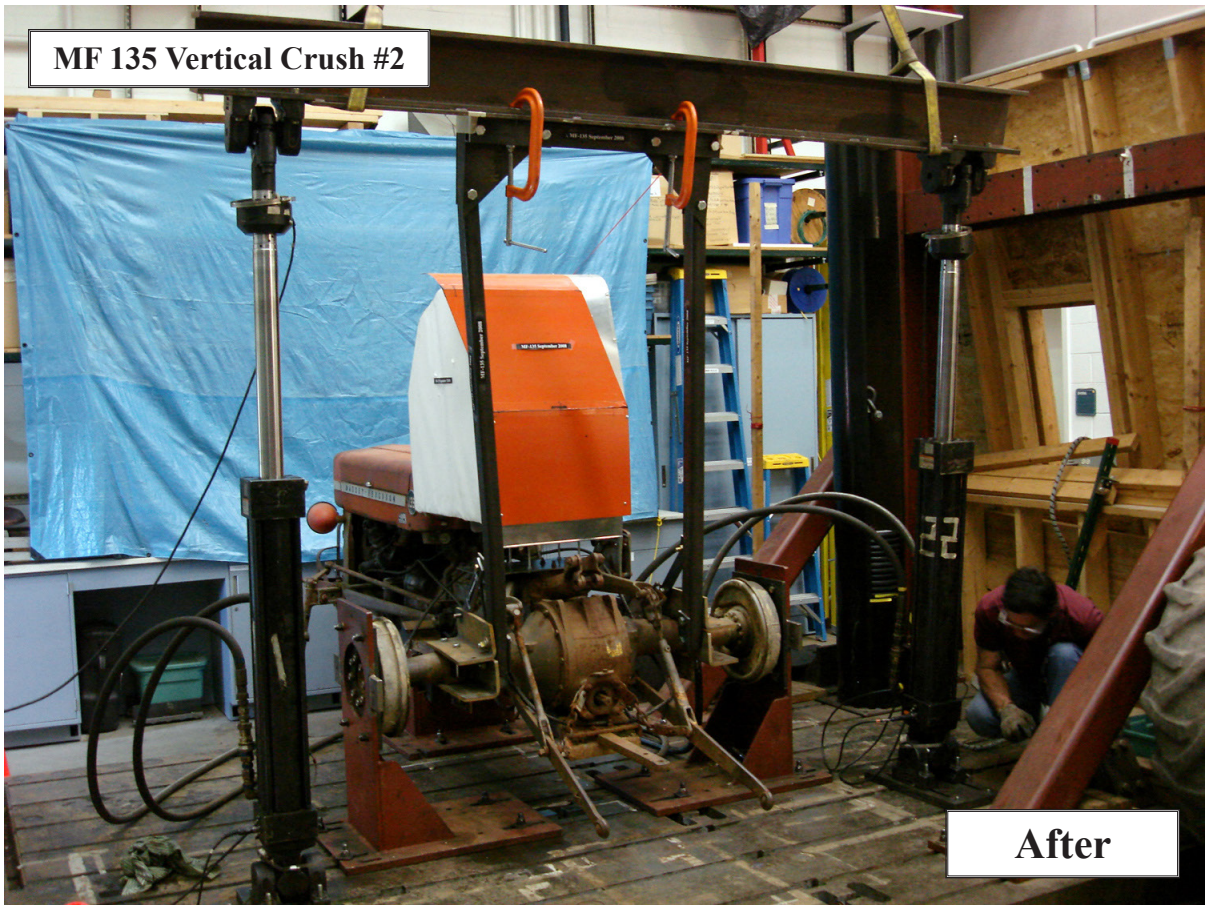

MF 135 Transverse Test
Before


MF 135 Transverse Test
After

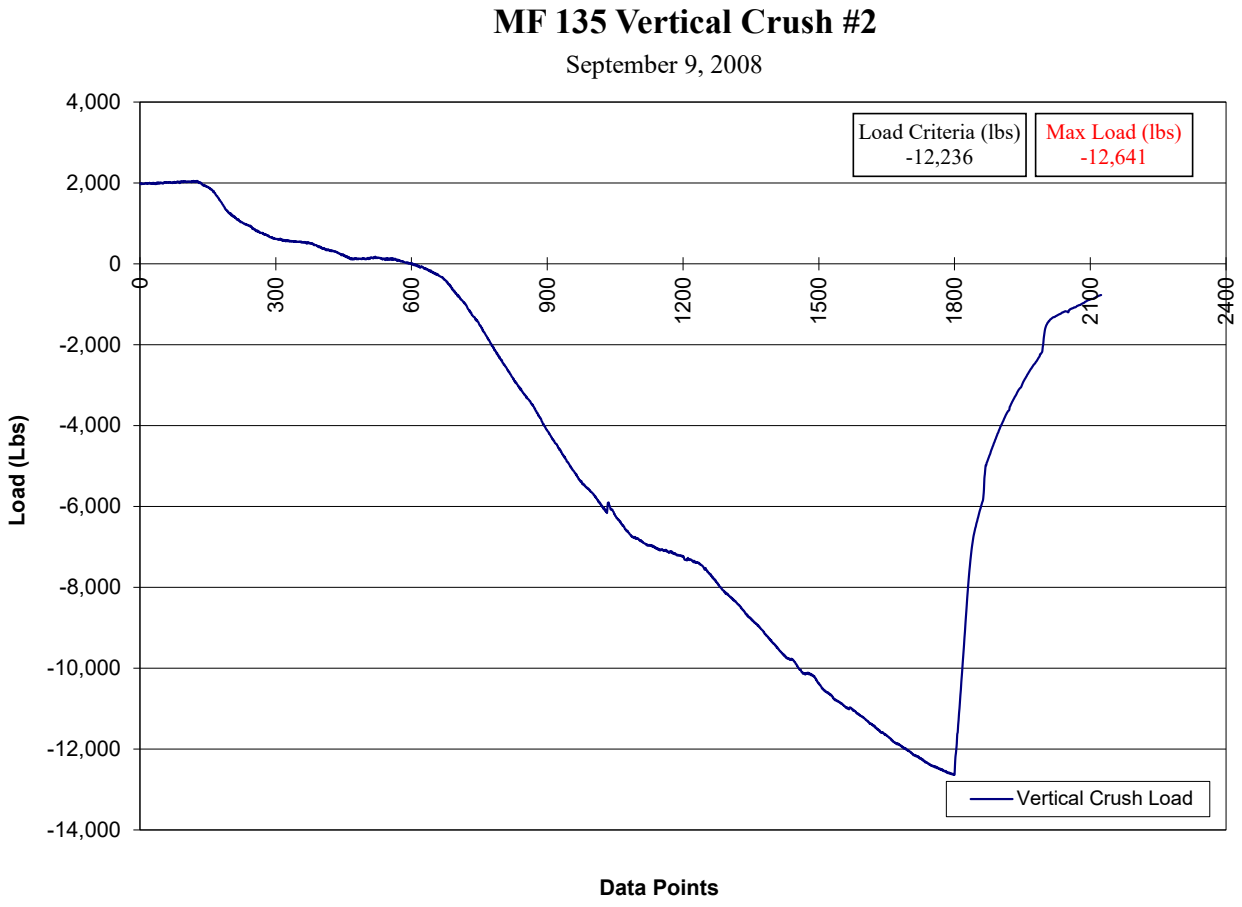
CROPS Lab Testing September 2008 MF 135 Series




MF 135 Vertical Crush #2
Before


MF 135 Vertical Crush #2
After

CROPS Lab Testing September 2008 MF 135 Series

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