



# Wire Rope Terminations

*presented by*

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# Purpose

To examine various wire rope termination techniques and determine the impact they have on wire rope strength. [Disclaimer: A scientifically valid test regime was not used in doing this evaluation.](#)

## ***Termination types (those identified for testing):***

- Mechanically swaged - one zinc coated copper compression sleeve
- Mechanically swaged - two zinc coated copper compression sleeves
- Mechanically swaged - two aluminum compression sleeves
- Mechanically swaged - one steel compression sleeve
- Flemish eye – one steel compression sleeve
- Mechanically swaged eye
- Spelter socket (epoxy wedge)
- U clamps
  - saddle on live end of wire rope
  - saddle on bitter end of wire rope
- Fist grips (3)
  - properly torqued
  - partially torqued
- Wedge socket
  - for 3/8" wire rope
  - for 5/16" wire rope



# Purpose

## ***Termination types, published effectiveness:***

➤ *Effectiveness = % of wire rope strength retained*

- Mechanical swages – 100%
- Mechanically swaged eye – 100%
- Flemish eye – 100%
- Spelter (epoxy wedge) – 100%
- Fist grips – 80%
- U clamps - 80%
- Wedge socket – 80%



# Testing – Setup

## *Test Fixture:*

- Universal tensile test machine
- Fixture attachments
  - Termination block
  - Wire rope holders

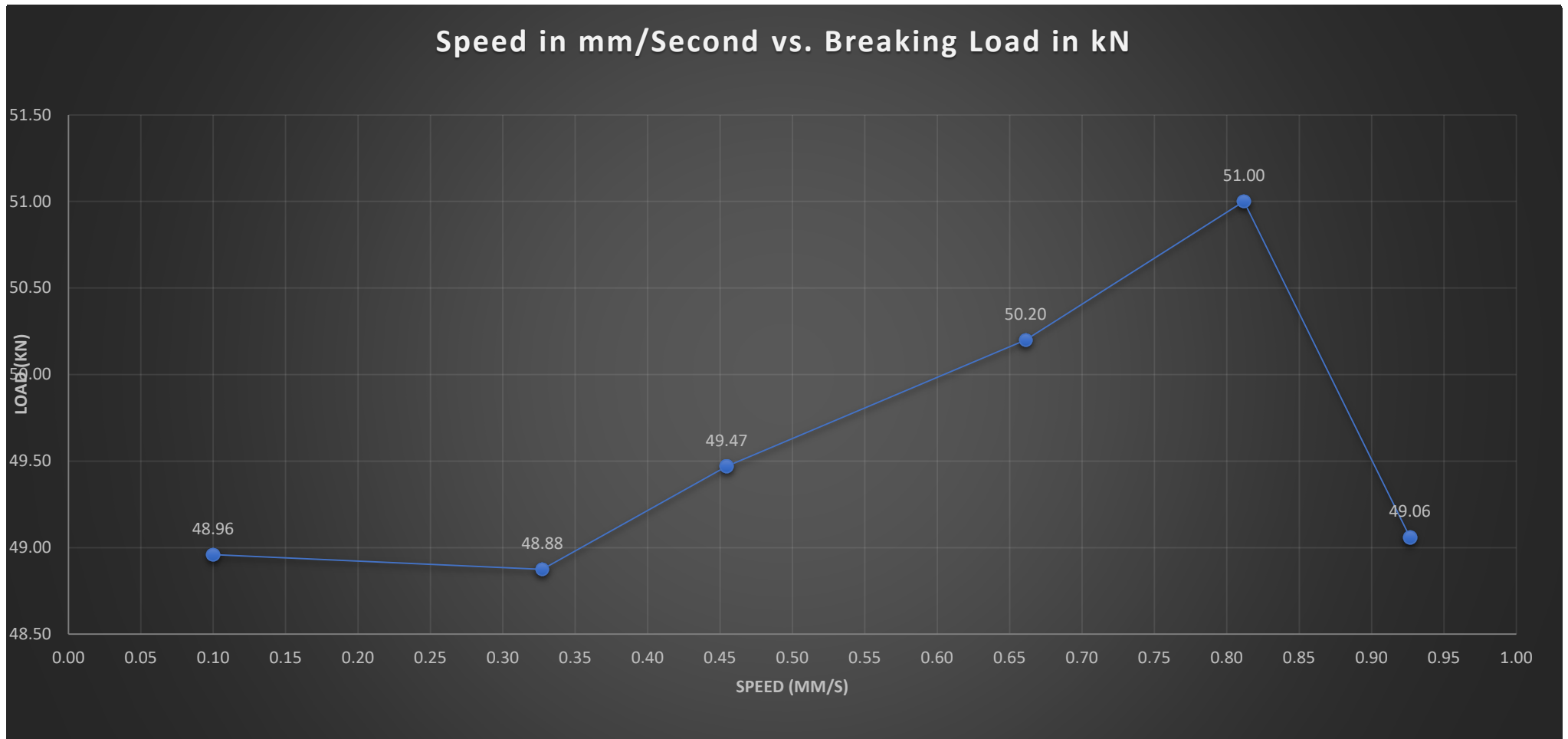
## *Cross head speed:*

- 0.10 kN/s
- 0.35 kN/s





# Test Set-up – Speed (strain rate sensitivity)





# Testing – Setup

## *Wire Rope:*

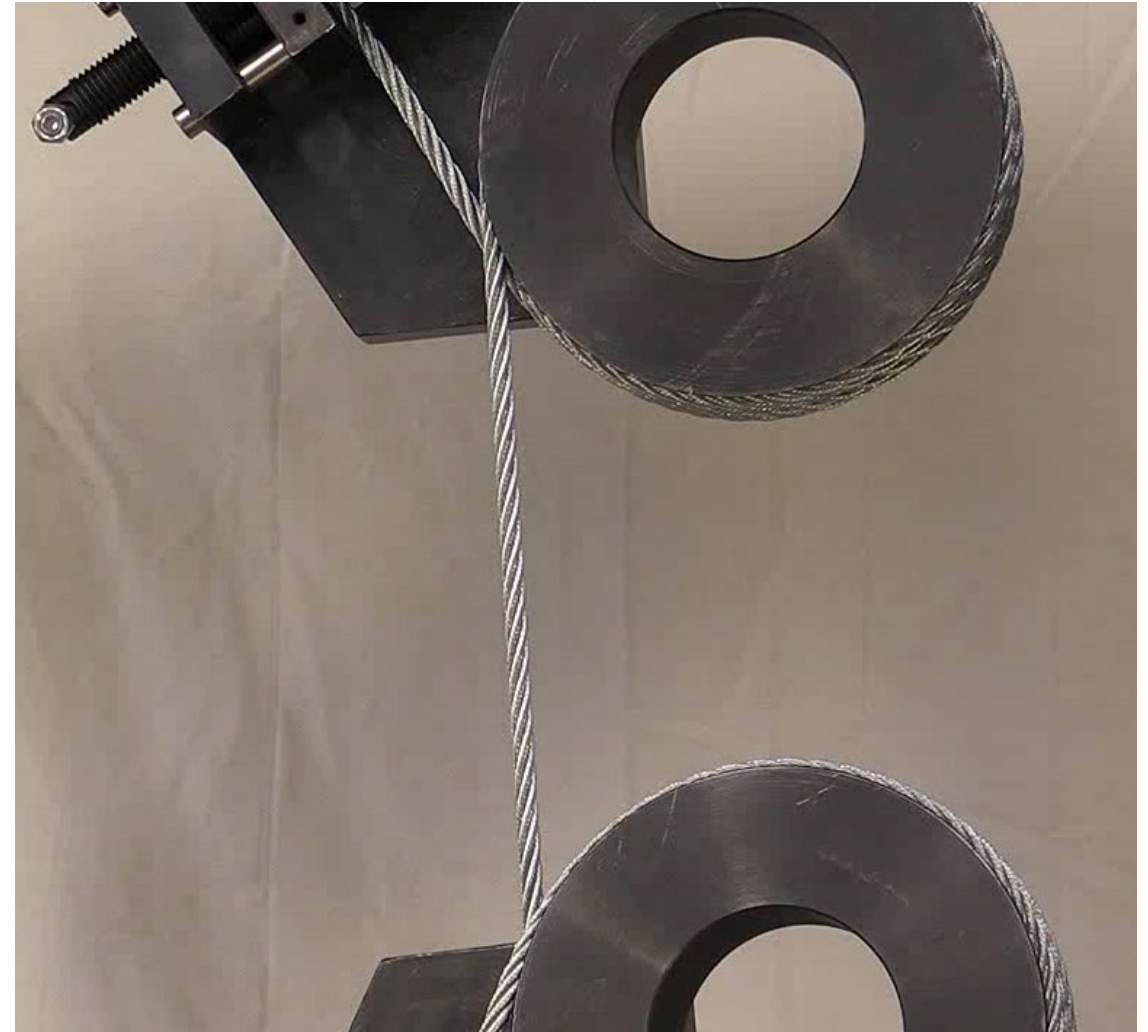
- 5/16" (8.0 mm) 5 x 26 WS, PFC, XXIP, RRL, preformed, galvanized wire rope with a catalog breaking strength of 10,725 lbf
- Country of origin: Thailand

## *Gage length:*

- 12" and 24"

## *Fixturing:*

- Multiple wraps around large diameter drum (to minimize/eliminate fixture induced stresses) with free end clamped





# Termination Types – Compression Sleeves

Mechanically swaged + (1) zinc-coated **Copper** compression sleeve



Mechanically swaged + (2) **Aluminum** compression sleeves



Mechanically swaged + (2) zinc-coated **Copper** compression sleeves



Mechanically swaged + (1) **Steel** compression sleeve





# Termination Types – Fist Grips

Fist grips - 3 **properly** torqued  
(30 ft-lbs)



Fist grips - 3 *improperly* torqued  
(10 ft-lbs)







# Termination Types – U-clamps

U clamps - installed **correctly**  
(saddle on live end of rope)



U clamps - installed **incorrectly**  
(saddle on bitter end of rope)





# Termination Types – Wedge Sockets

**5/16”** wedge socket  
(correctly sized for wire diameter)



**3/8”** Wedge socket  
(oversized for wire diameter)





# Termination Types – Other Types

Swaged eye



Flemish eye



Spelter socket (epoxy)





# Test Results

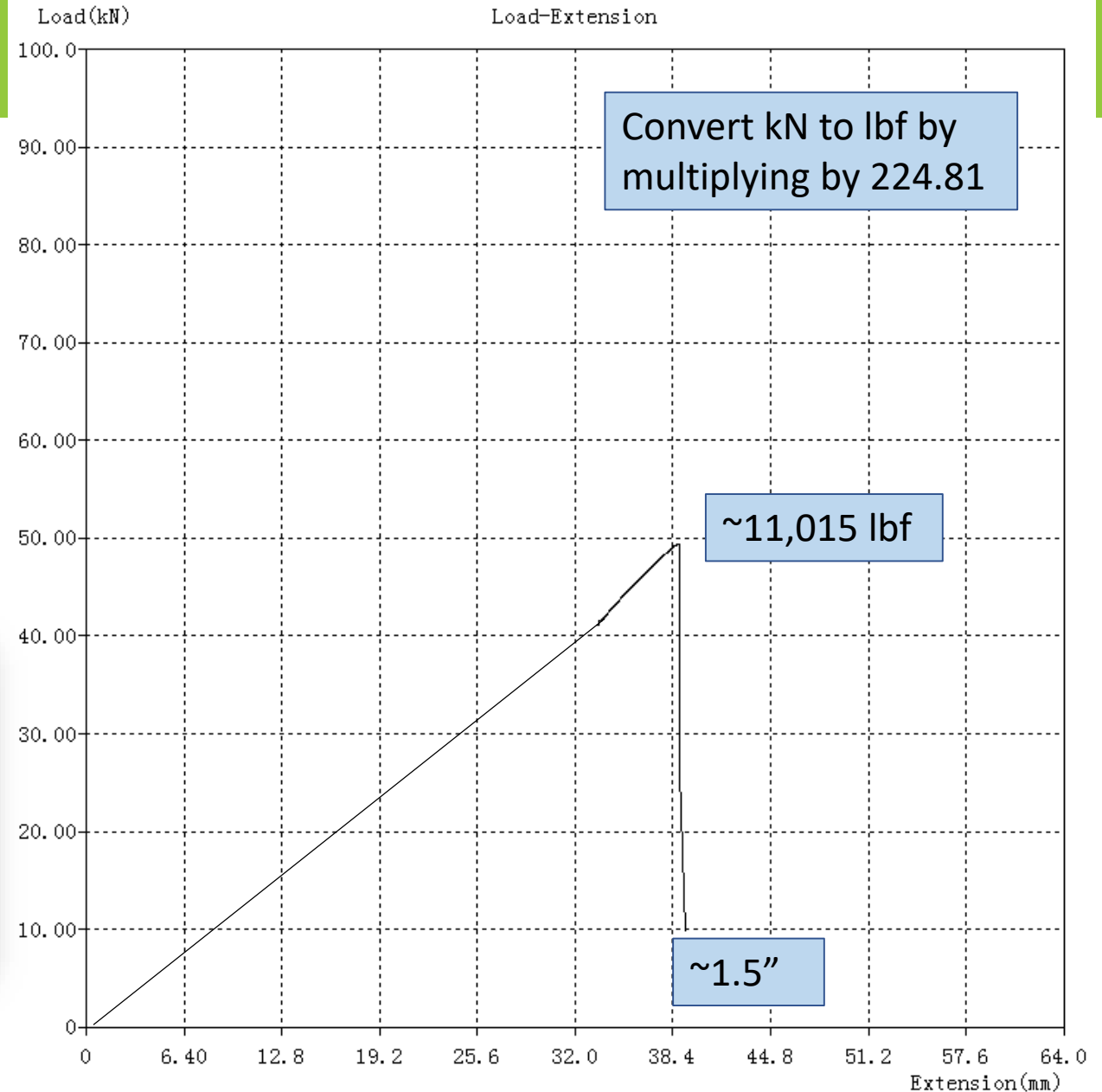
## Mechanically swaged + (1) zinc-coated **Copper** compression sleeve

### Definition:

- Machine swaged with Thimble-eye and a copper compression sleeve

### Observations:

- Failure occurred in the wire rope, not at the termination





# Test Results

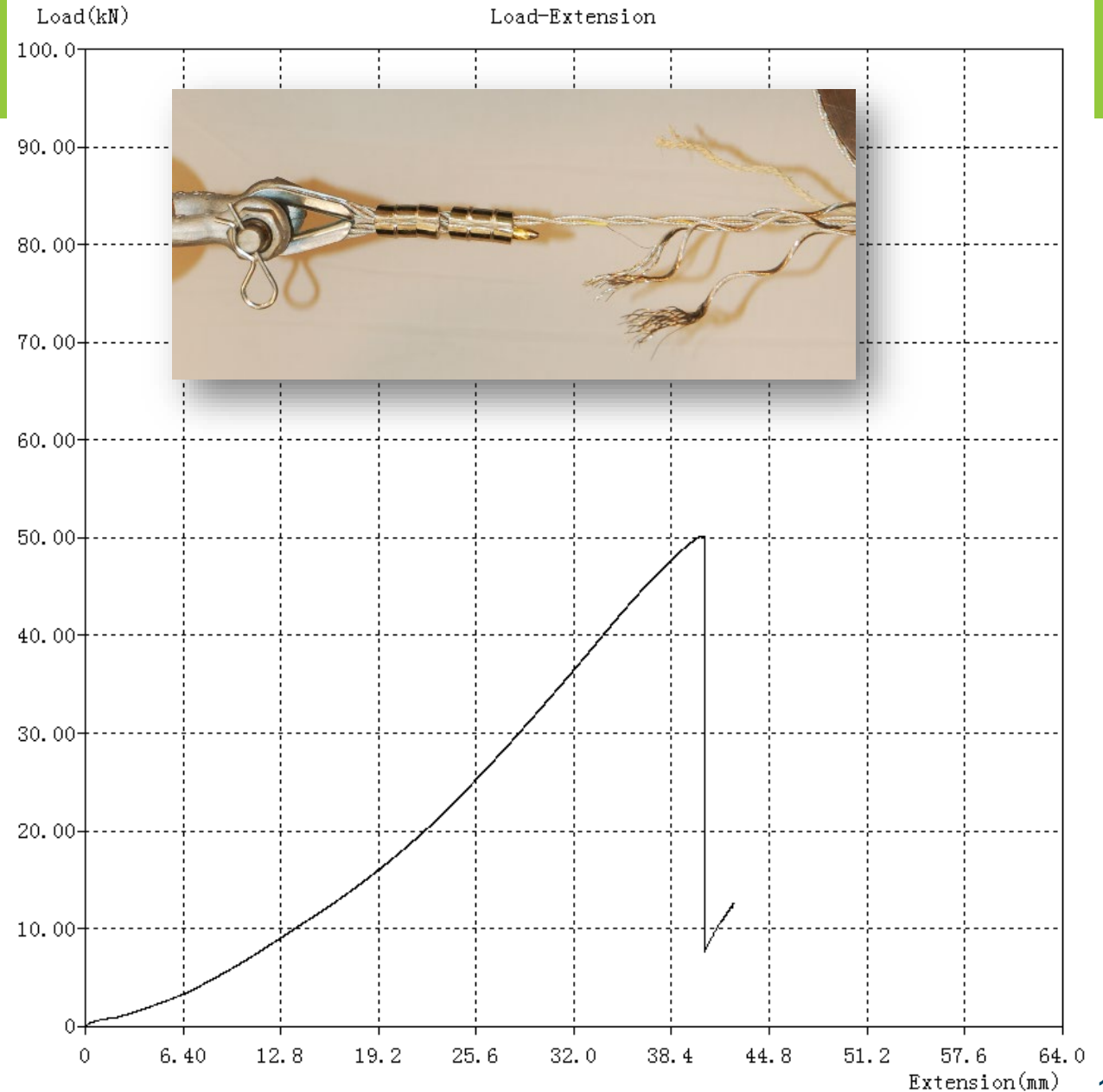
## Mechanically swaged + (2) zinc-coated **Copper** compression sleeves

### Definition:

- Machine swaged with Thimble-eye and 2 copper compression sleeves

### Observations:

- Failure occurred in the wire rope adjacent to the lower compression sleeve





# Test Results

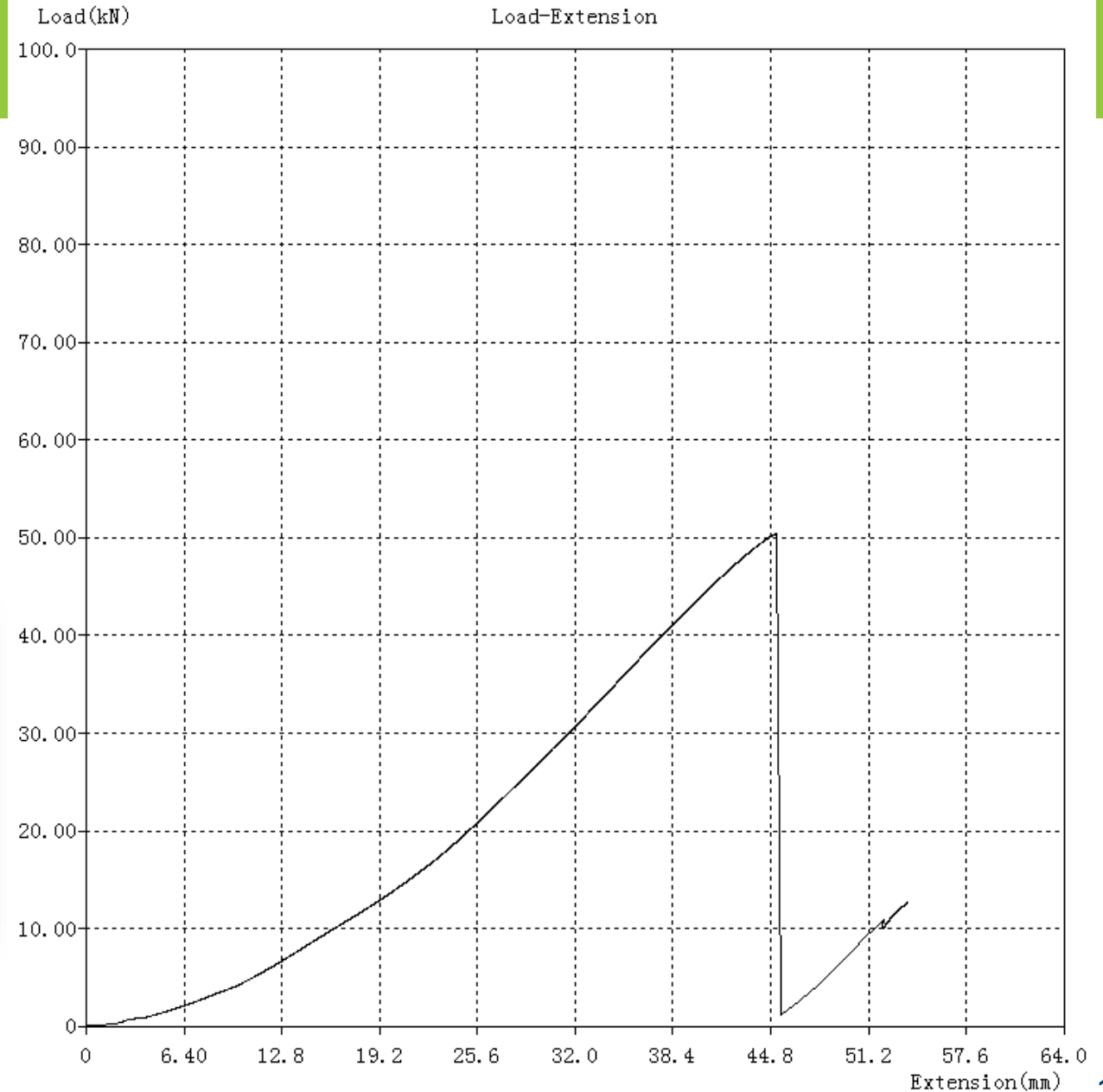
## Mechanically swaged + (2) Aluminum compression sleeves

### Definition:

- Machine swaged with Thimble-eye and 2 aluminum compression sleeves

### Observations:

- Failure occurred in the wire rope, not at the termination





# Test Results

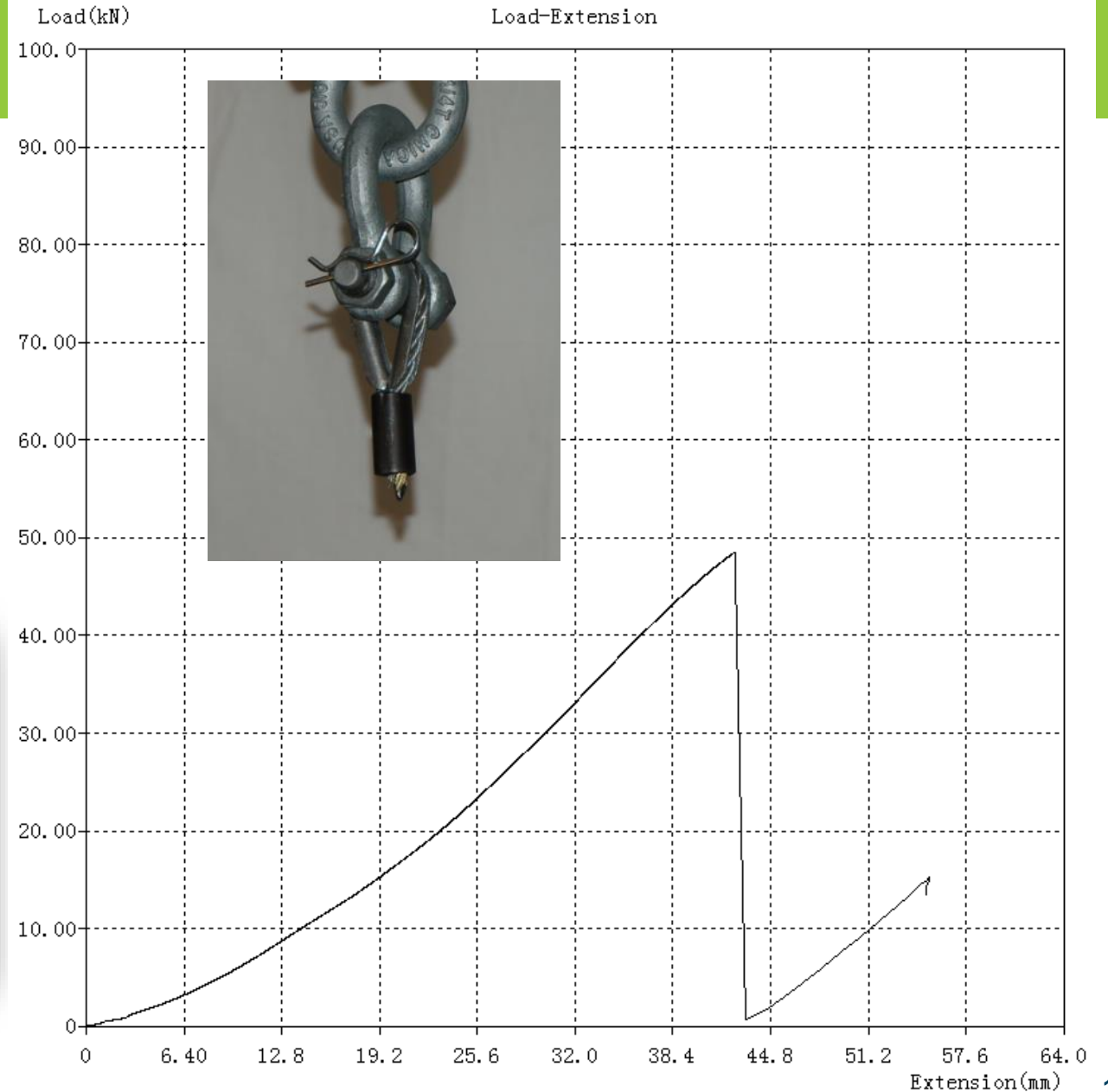
## Mechanically swaged + (1) Steel compression sleeve

### Definition:

- Machine swaged with Thimble-eye and a steel compression sleeve

### Observations:

- Failure occurred in the wire rope just below the swage
- All strands failed, complete separation of the wire rope





# Test Results

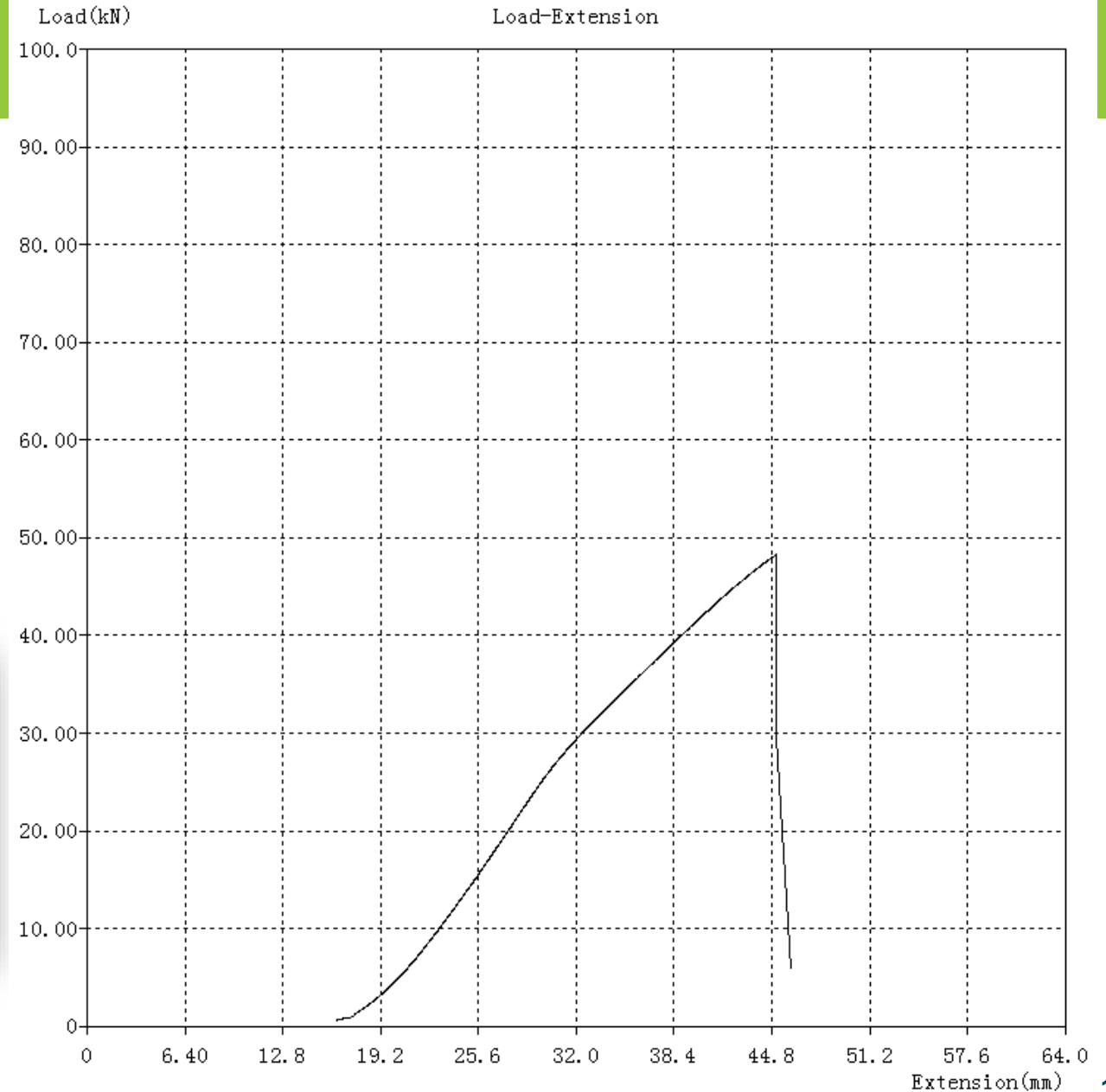
Three (3) Fist Grips properly torqued to 30 ft-lbs

*Definition:*

- Fist Grips = J-clamps or Cable Clips
- Thimble-eye and 3 Fist Grips installed with proper torque on fasteners

*Observations:*

- Failure occurred in the wire rope just below the lowest fist grip installed







# Test Results

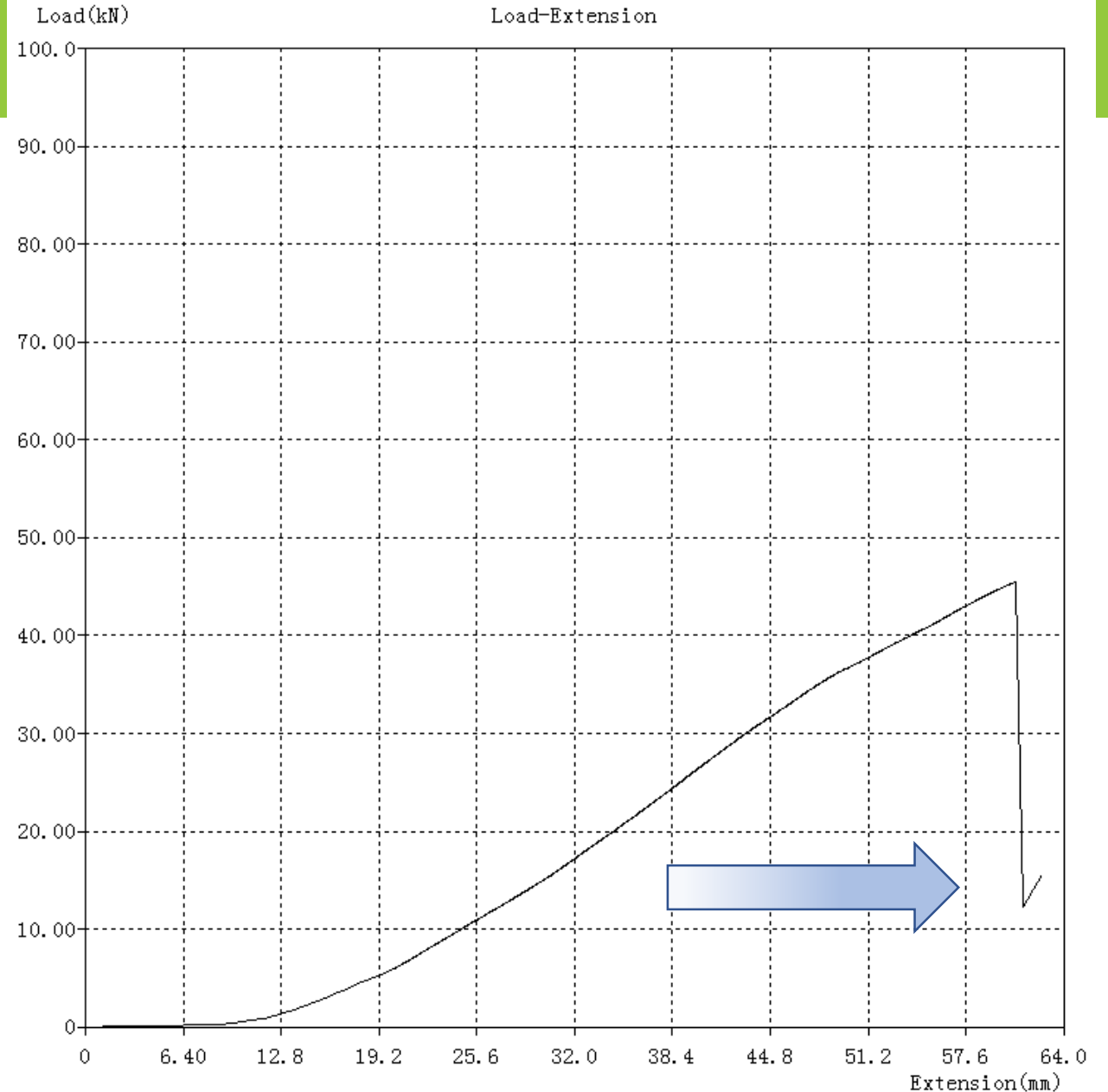
## Three (3) Fist Grips *improperly* torqued to **10 ft-lbs**

### Definition:

- Fist Grips = J-clamps or Cable Clips
- Thimble-eye and 3 Fist Grips installed with improper torque on fasteners
- Fasteners torqued to only 10 ft-lbs.

### Observations:

- Wire rope slipped significantly prior to wire rope failure
- Thimble exhibited severe distortion





# Test Results

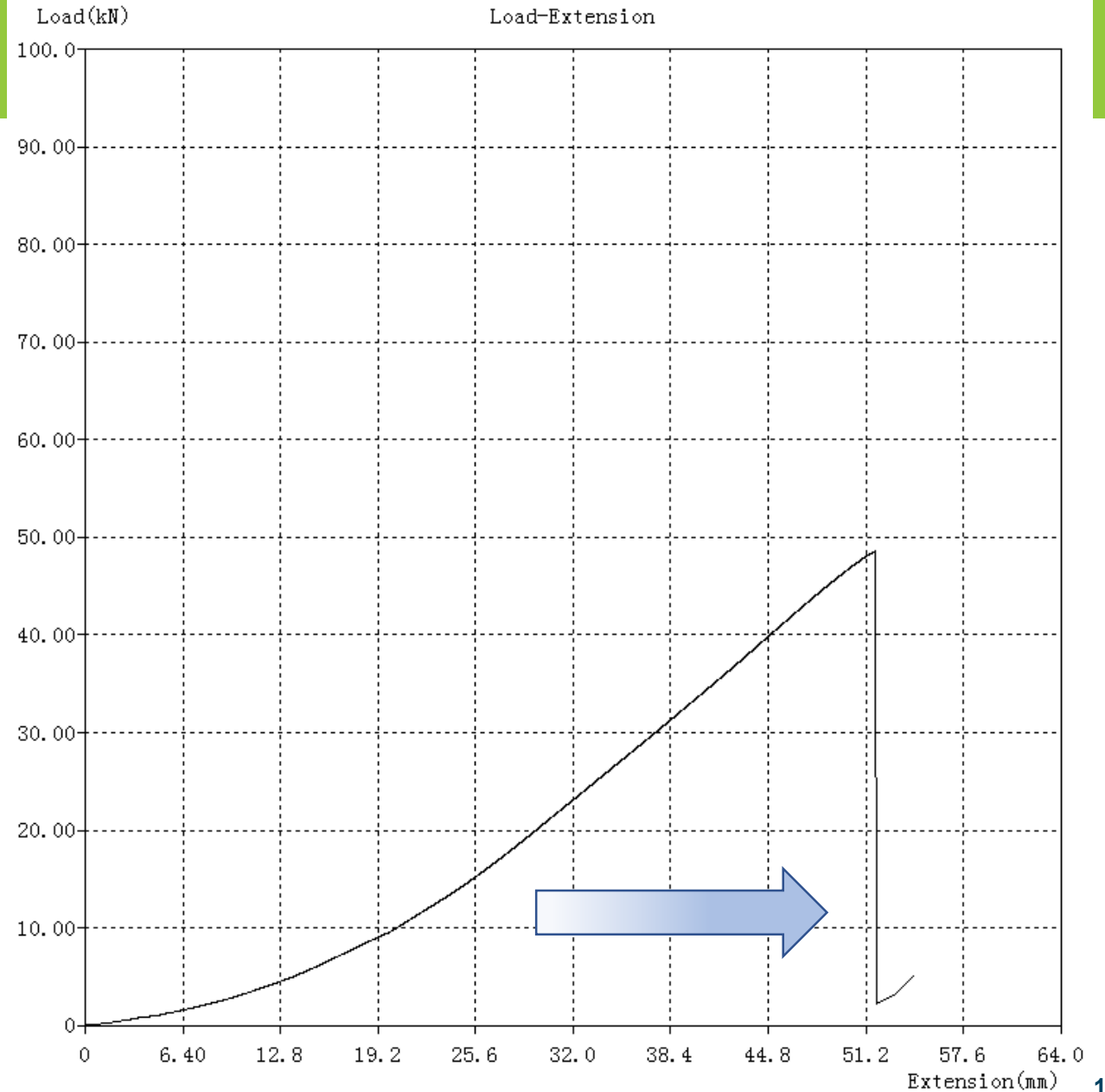
## U-clamps installed correctly

### Definition:

- Saddle on live end of rope

### Observations:

- Failure occurred in the wire rope under or in the vicinity of the lower U-clamp





# Test Results

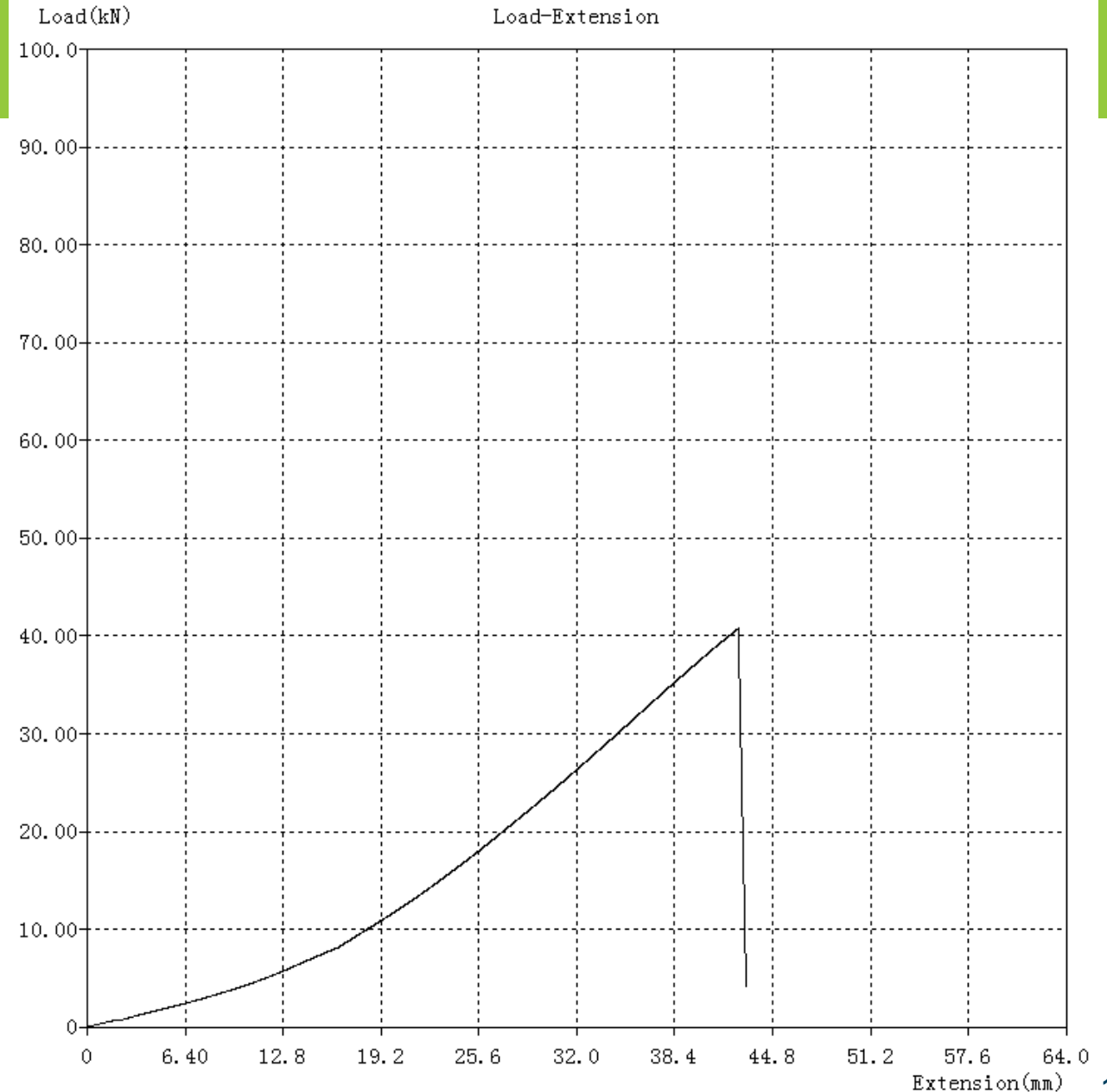
## U-clamps installed *incorrectly*

### Definition:

- Saddle on bitter end of rope

### Observations:

- Failure occurred in the wire rope between the two U-clamps





# Test Results

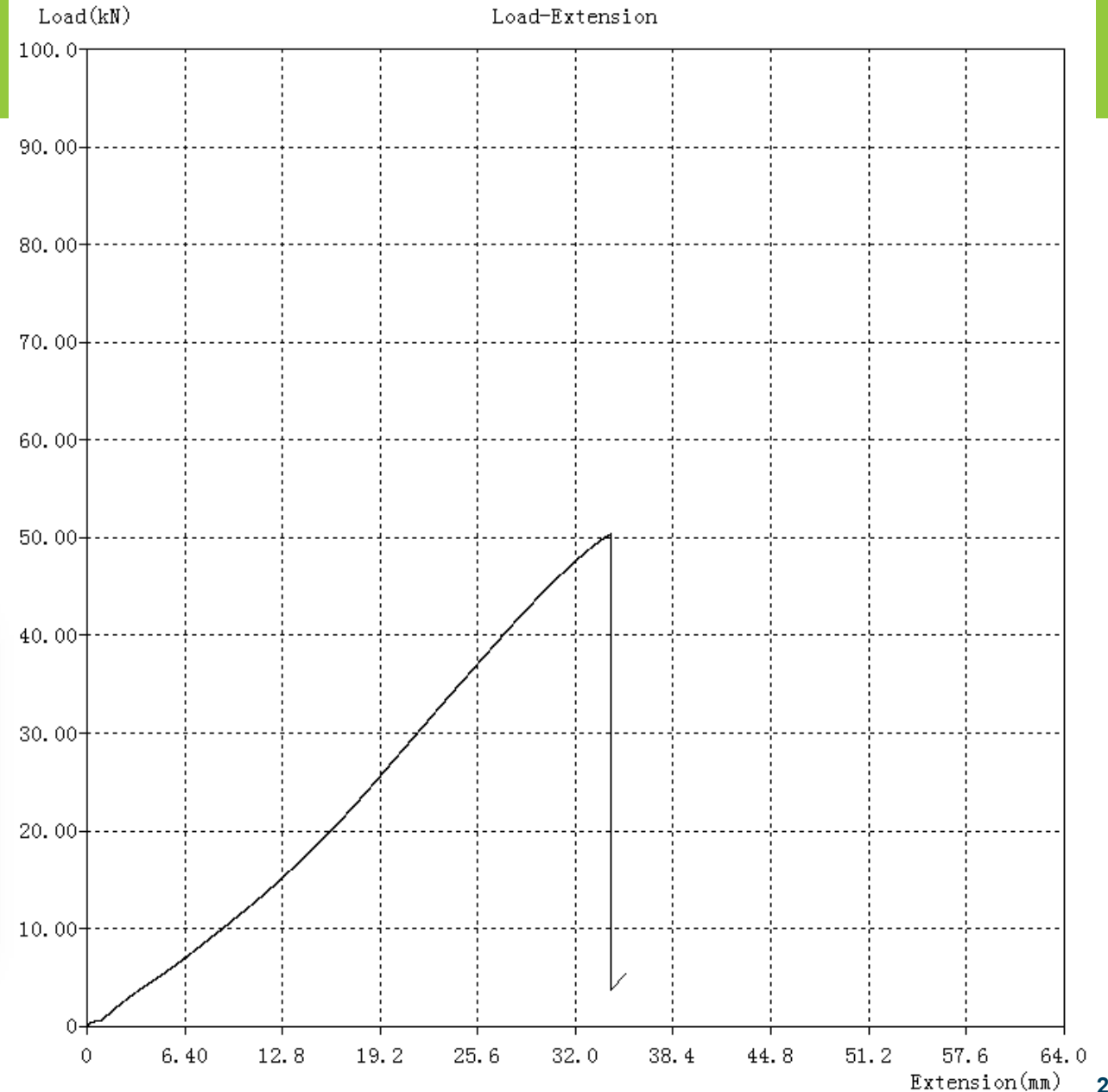
## Swaged eye

### Definition:

- Machine swaged forged eye - also called a closed swage socket

### Observations:

- Failure occurred in the wire rope, not at the termination





# Test Results

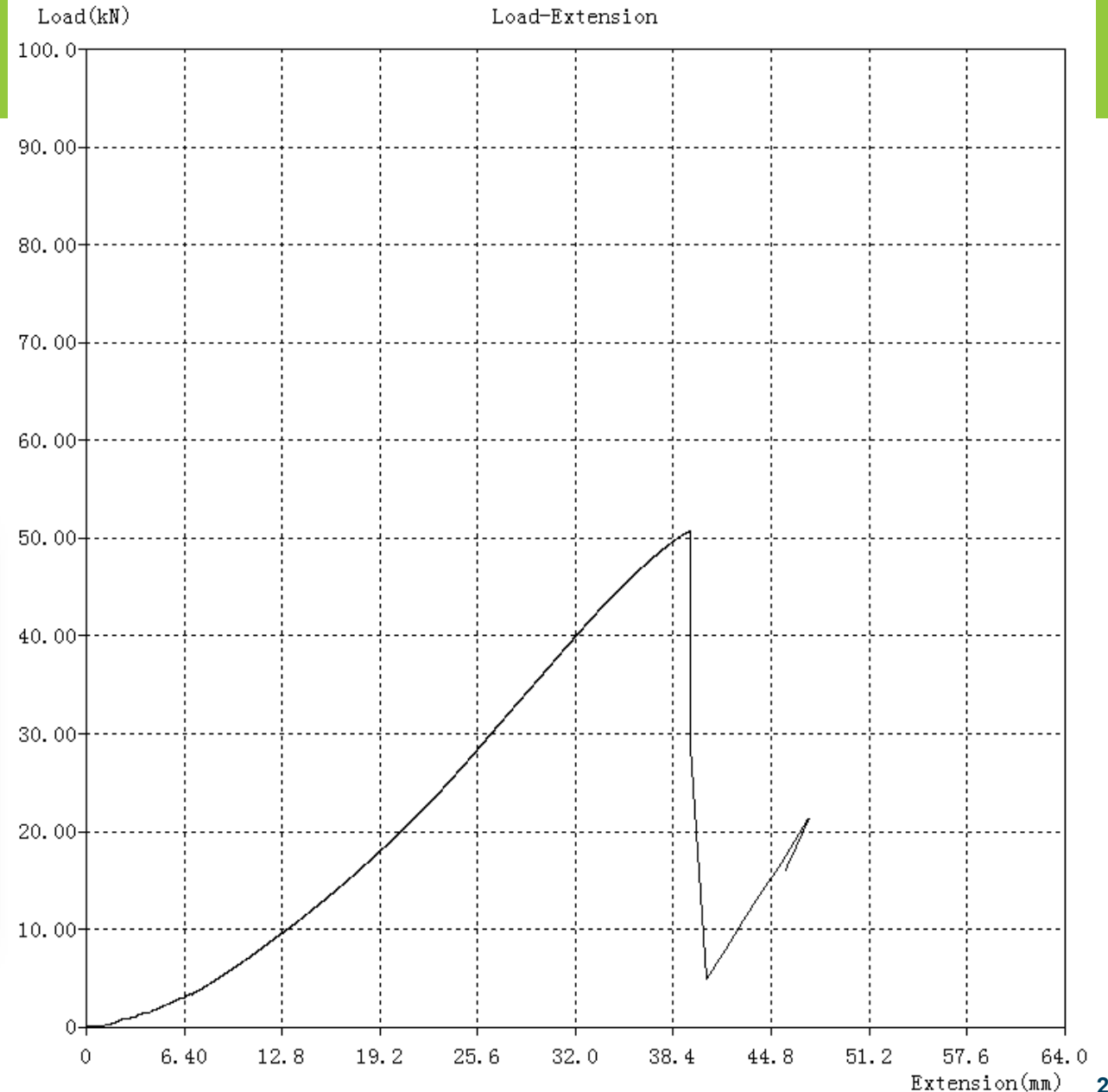
## Spelter socket (epoxy)

Definition:

- Wire rope secured with epoxy wedge in socket

Observations:

- Failure occurred in the wire rope, not at the termination





# Test Results

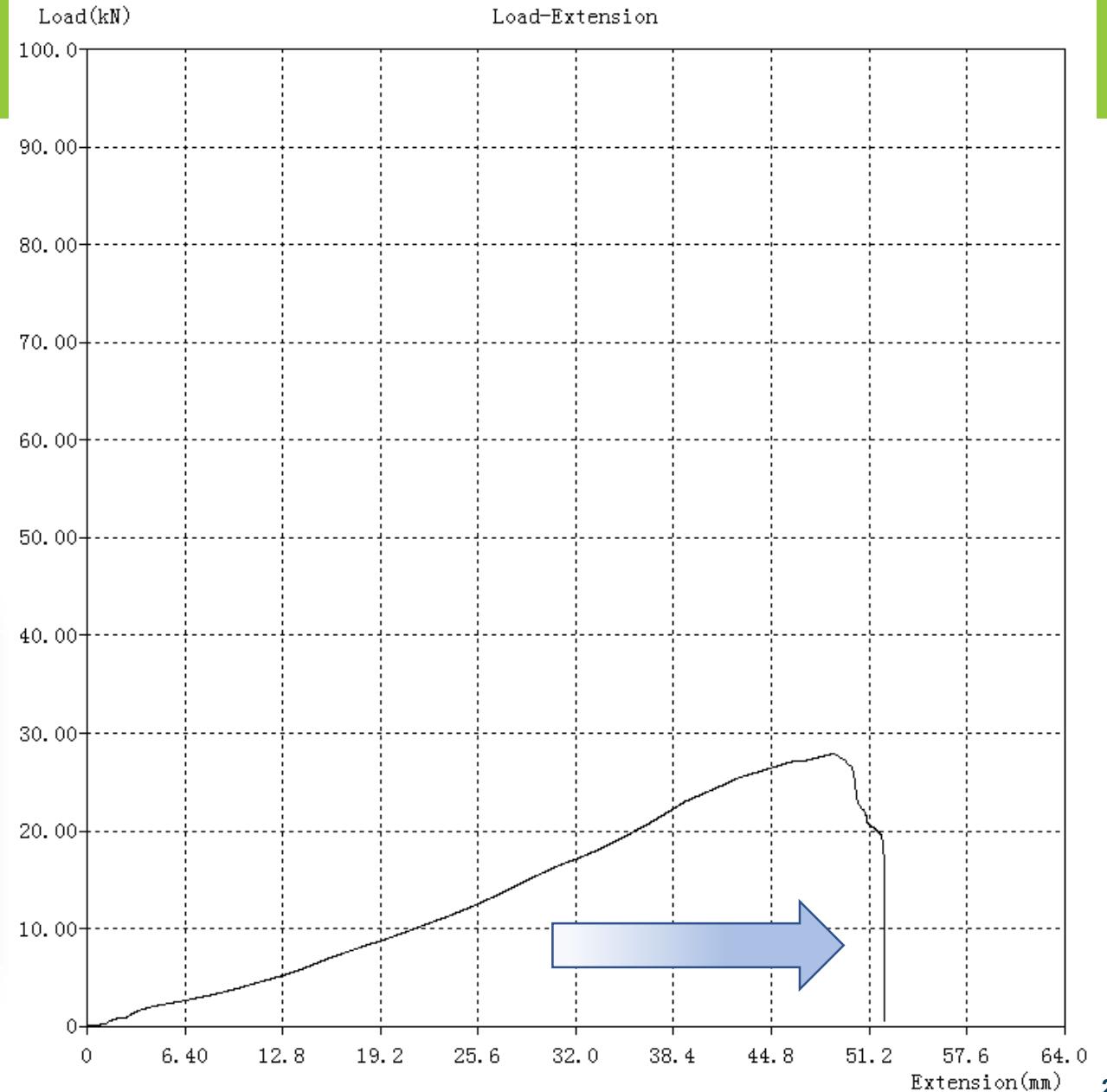
## 3/8" Wedge Socket

### Definition:

- A wire rope attachment in which the rope lies in a groove between a wedge and housing, so that pull on the rope tightens the wedge

### Observations:

- Experienced significant slippage prior to wire rope failure
- Wire rope pulled free from the termination after wire rope failure





# Test Results

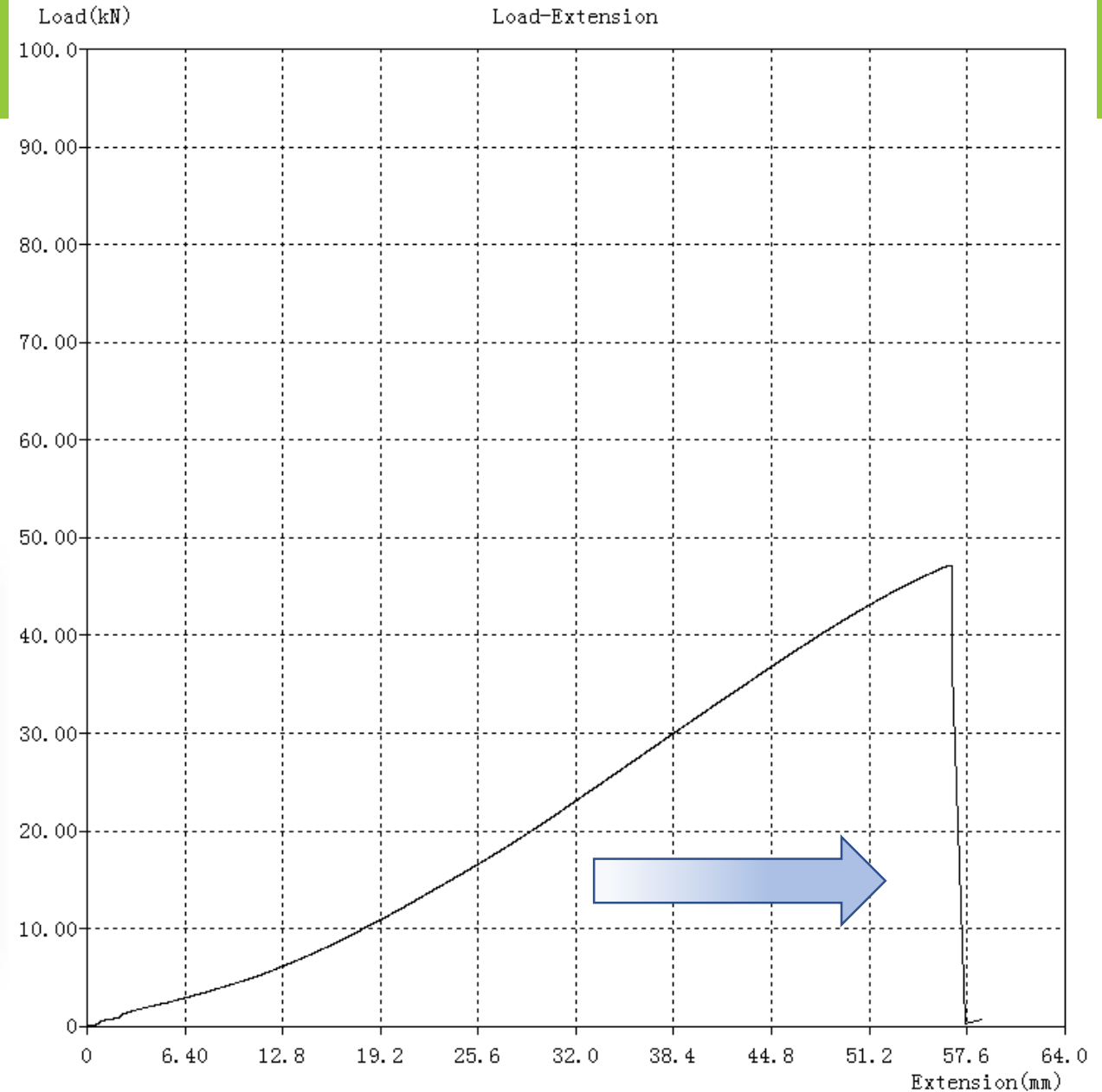
## 5/16" Wedge Socket

Definition:

- A wire rope attachment in which the rope lies in a groove between a wedge and housing, so that pull on the rope tightens the wedge

Observations:

- Failure occurred in the wire rope below the wedge body





# Test Results

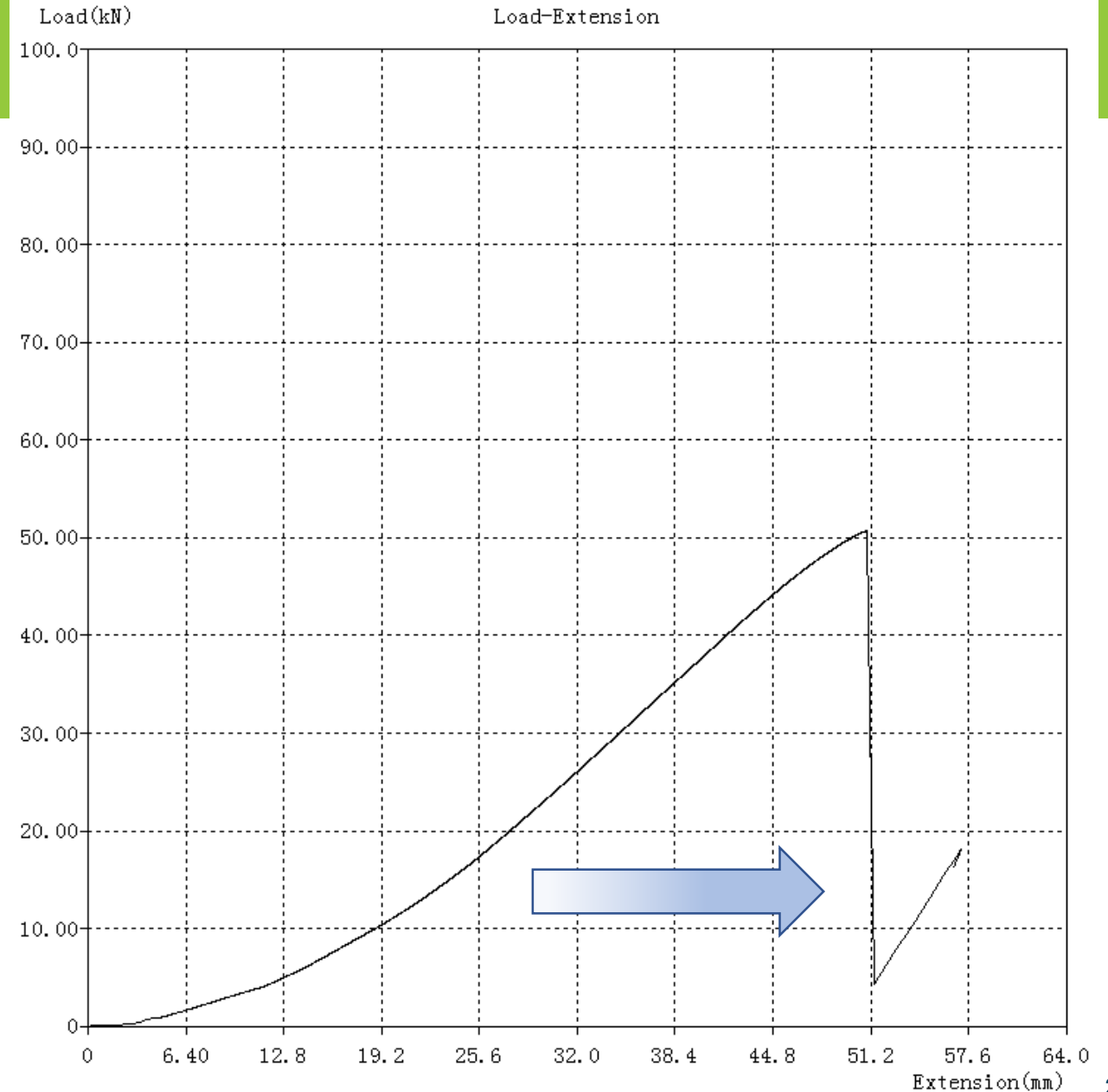
## Flemish Eye

Definition:

- Thimble with wire rope end woven back into itself and secured with a single steel compression sleeve

Observations:

- Failure occurred in the wire rope, not at the termination

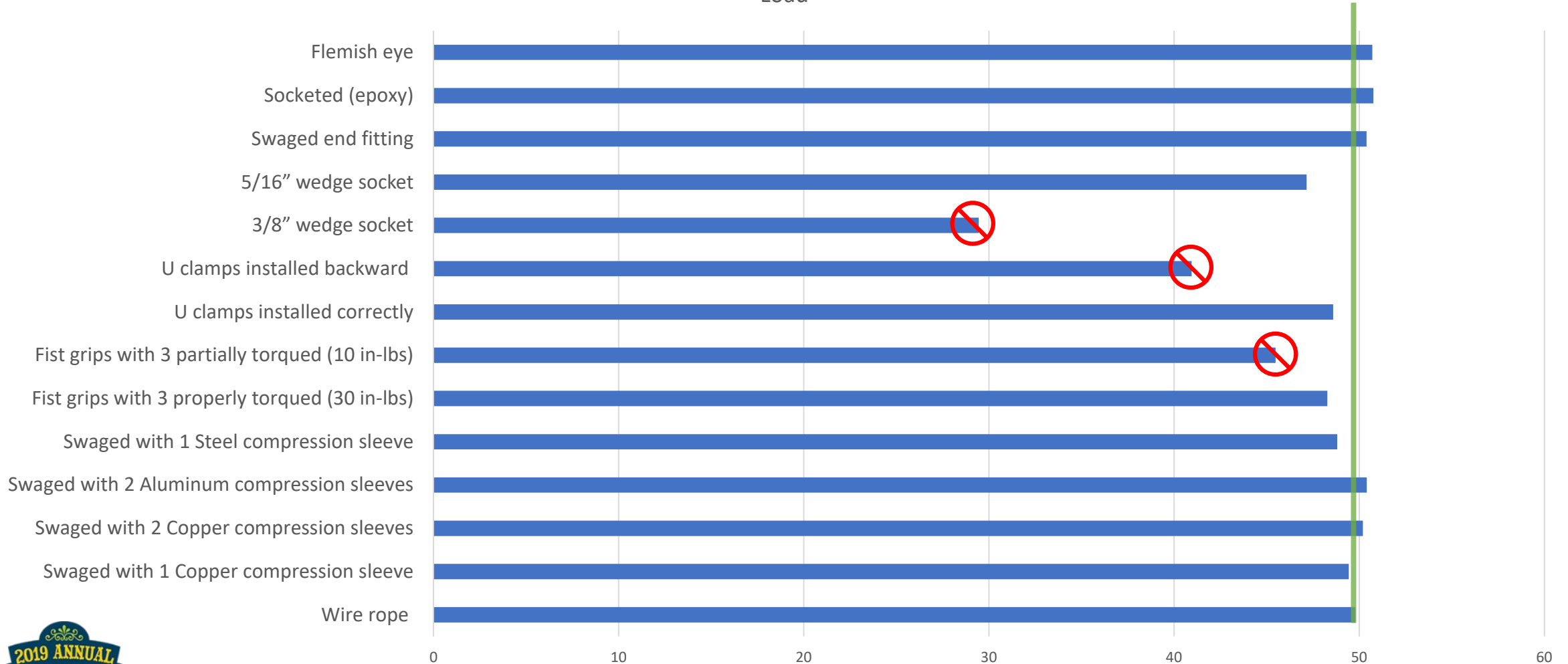






# Test Results – Breaking Load Comparison

Load 11,160 lbf vs. 10,725 lbf catalog value





# Findings

## *Issues Identified*

### “U” (saddle) Clamps

- Wire rope damage at clamp
- Rope distortion visible even before wire rope is under load



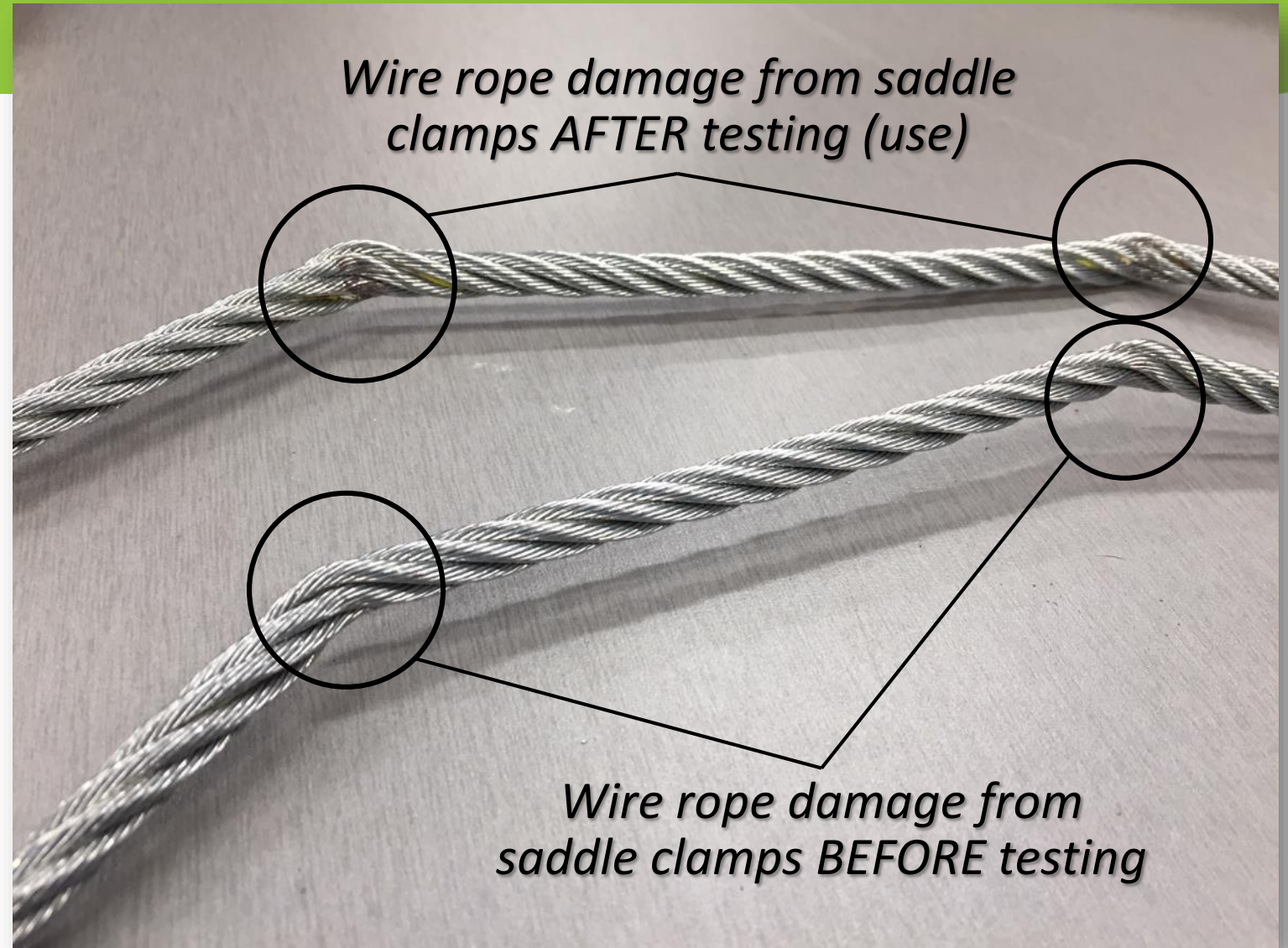


# Findings

## Issues Identified

### “U” (saddle) Clamps

- Even when properly installed, saddle clamps caused damage to the wire rope



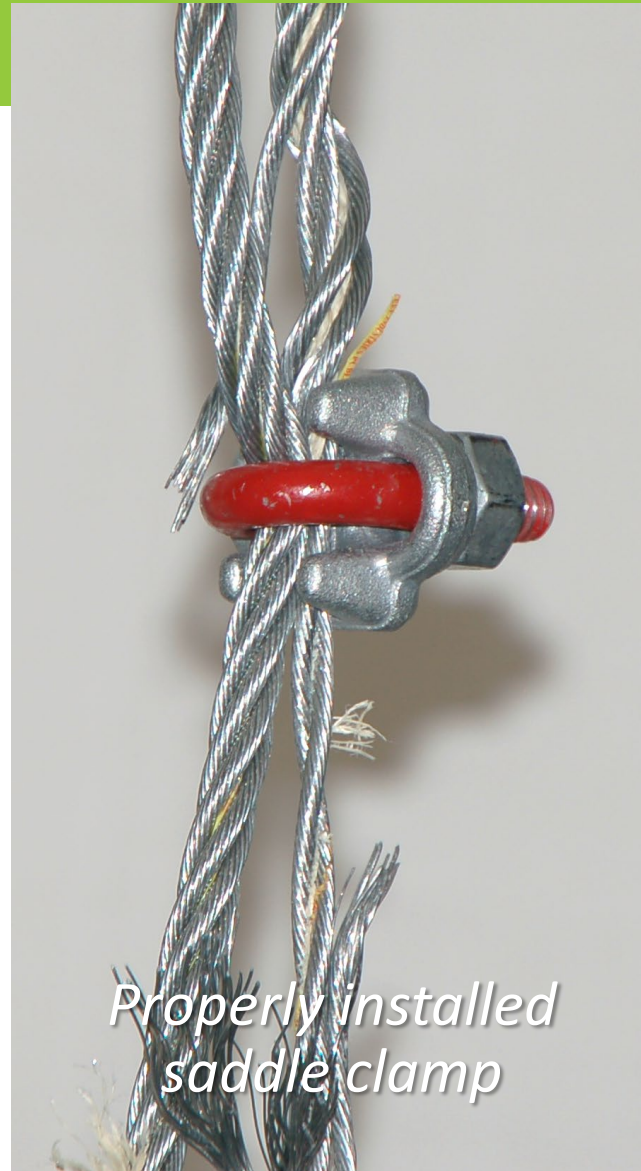


# Findings

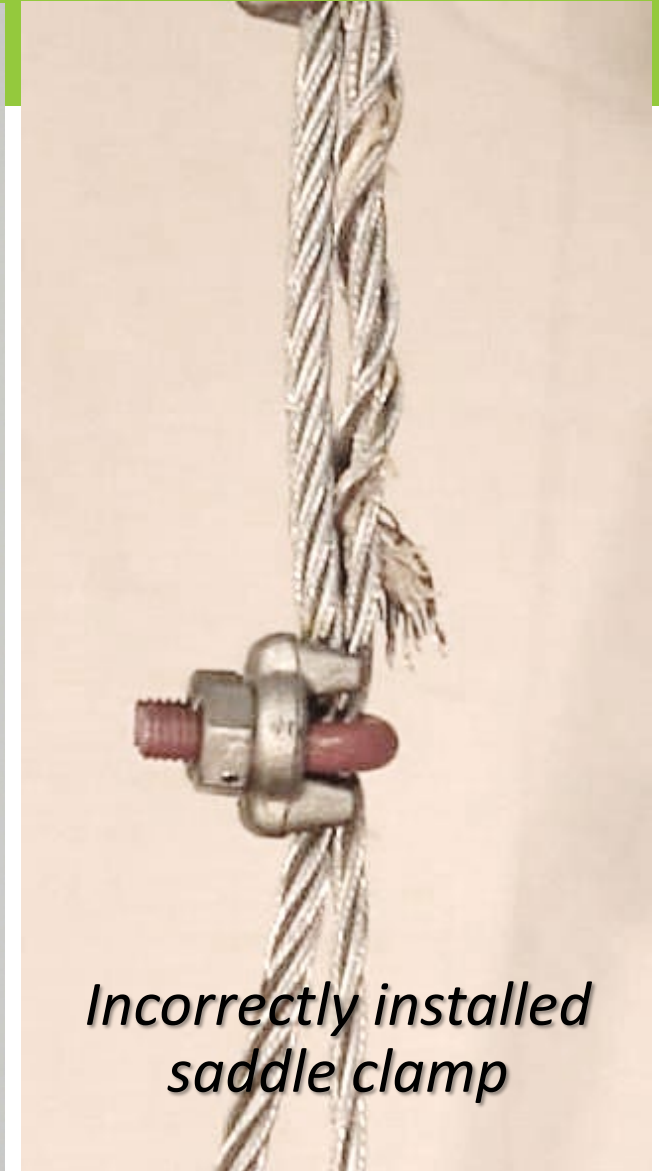
## *Issues Identified*

### **“U” saddle Clamps**

- Wire rope broke at the U-clamp in both tests



*Properly installed  
saddle clamp*



*Incorrectly installed  
saddle clamp*



# Findings

## *Issues Identified*

### **Fist Grips (“J” clamps)**

- When improperly torqued, wire rope slipped significantly prior to rope failure
- Thimble distorted and bent



*Video speed adjusted for viewability.*

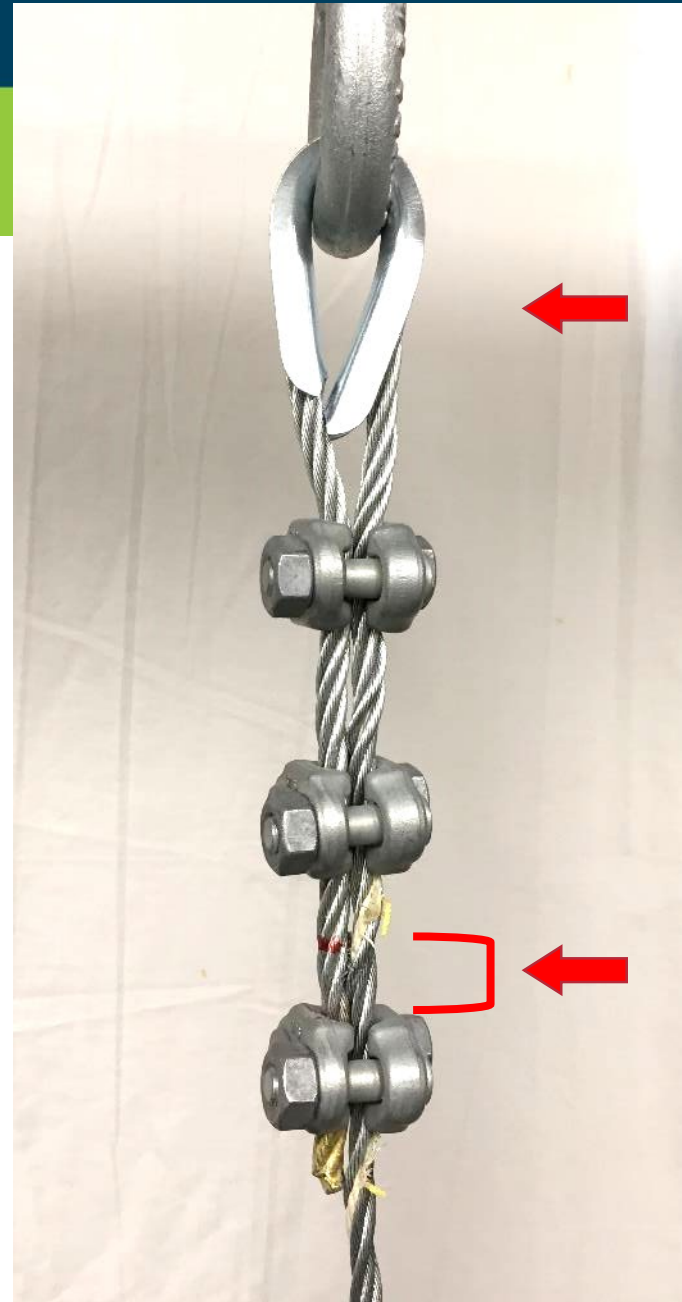


# Findings

## *Issues Identified*

### **Fist Grips (“J” clamps)**

- Improperly torqued
- Wire rope slipped significantly prior to wire rope failure
- Thimble distorted and bent





# Findings

## *Issues Identified*

### **3/8" Wedge Clamp**

- Weakest termination type in this testing
- Experienced significant slippage prior to wire rope failure



Watch **red** markings on right side to witness slippage.

*Video speed adjusted for viewability.*



# Findings

## *Issues Identified*

### **3/8" Wedge Clamp**

- Weakest termination type in this testing
- Experienced significant slippage prior to wire rope failure
- Failure also damaged the clamp itself





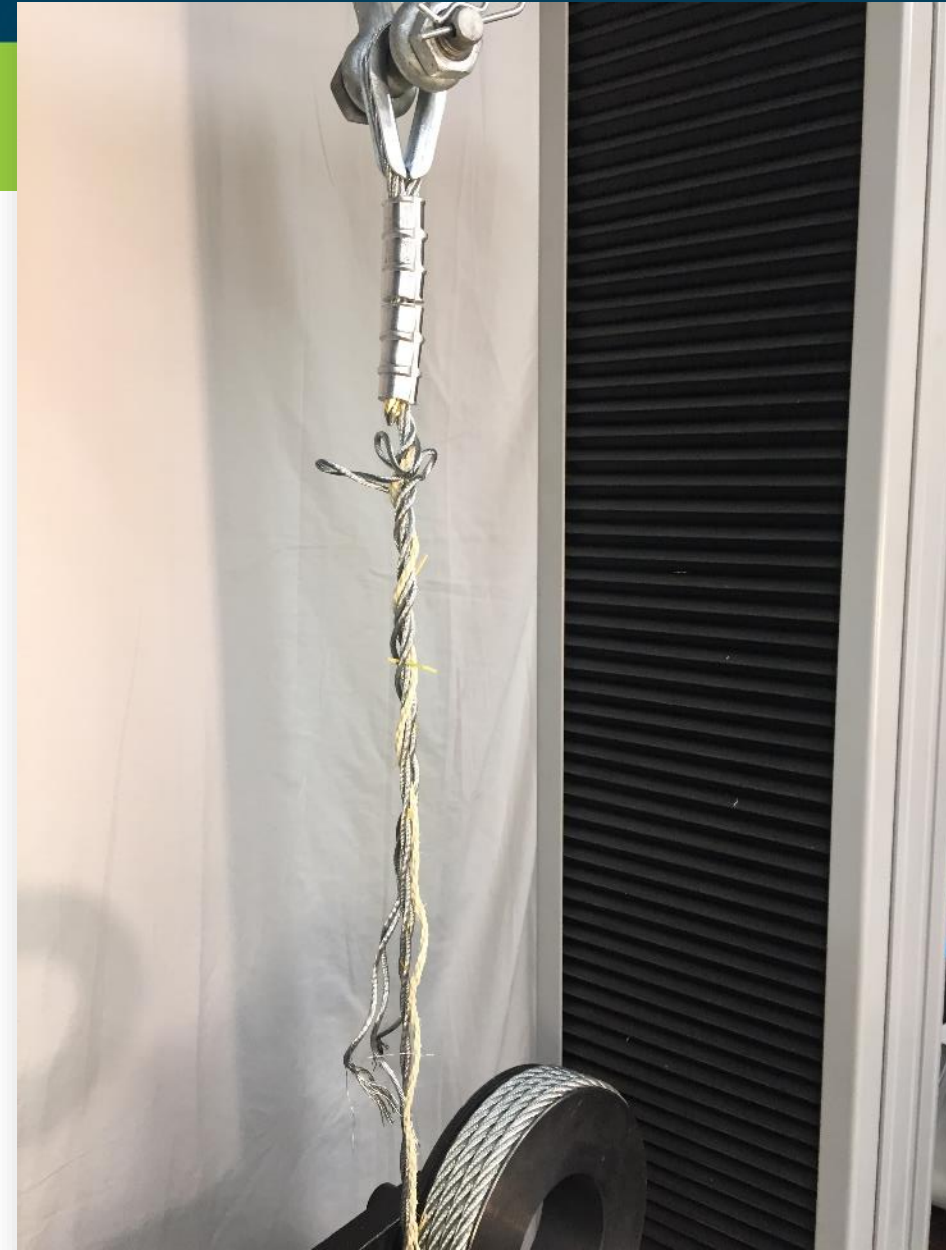


# Findings

## *Issues Identified*

### **Aluminum Compression Sleeves**

- Aluminum compression sleeves performed acceptably
- Use caution, some aluminum sleeve manufacturers do not recommend use of their product in lifting applications





# Conclusions

There are many Wire Rope Termination techniques that are effective when properly implemented. Based on the results of this particular set of experiments, as well as manufacturer recommendations, we can say:

## ***What types of terminations worked well?***

- Swaged - two copper compression sleeves
- Flemish eye - one steel compression sleeve
- Swaged socket
- Socketed (epoxy wedge)

## **What types performed adequately?**

- Swaged - one copper compression sleeve
- Swaged - one steel compression sleeve
- Fist grips (3) – if properly installed
- 5/16” wedge socket

## ***What types of terminations performed poorly?***

- Fist grips – when install torque is not controlled
  - Do you know the torque on your fist grips?
- U clamps
  - for a variety of reasons
- 3/8” wedge socket
  - termination hardware needs to be properly sized for the wire rope being used

## **Exception:** Swaged - aluminum compression sleeves

- performed WELL in testing
- follow manufacturer’s recommendation on acceptable use (lifting?)



# Inspections

*Remember, wire rope is a “consumable” - it begins to deteriorate upon first use*

## **Field Inspections:**

- Inspection **must** be performed by a competent person.

## **Inspection Frequency:**

- Inspect **ALL** wire ropes at the start of each work shift and after any occurrence that could affect a wire rope’s integrity. The entire length of the wire rope should be inspected.



# Inspections

## *Wire Rope Replacement*

Wire ropes MUST be replaced if ANY of the following conditions exist (excerpt from OSHA regulations):

- Any physical damage which impairs the function and/or strength of the wire rope.
- Kinks that might impair tracking and/or wrapping of wire rope around the drum or sheave of hoists.
- Six randomly distributed wires broken in one rope lay, or 3 broken wires in one strand in one rope lay.
- Loss of more than 1/3 of the original diameter of the outside wires due to abrasion, corrosion, scrubbing, flattening, or peening (how to measure?)
  - 5% reduction in the original diameter (in lieu of the OSHA requirement)
- Heat damage caused by a torch, or any damage caused by contact with electrical wires.
- Damage caused by improper grounding when welding from a suspended platform.
- Evidence that the secondary brake has been activated during an over speed condition and has engaged the suspension rope.

**This is the minimum criteria. You may establish more stringent criteria as appropriate.**



**Thank you!**

## Questions?

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