AERIAL APPARATUS
OPERATIONS AND RESCUE

Tyler Shook / David Kang
PURPOSE

• Not a driver / operator class
• Understand your equipment
• Have a better understanding of Forces
• See apparatus through new eyes
• Using the Aerial for a “high pick point”
  • RPM / Patient Packaging review
PURPOSE

So this does not happen:
RESOURCES

• Dr. James Burrell, Ph.D.
  • Mission College, Santa Clara, CA

• 5 year study on Aerial accidents / incidents
• Most incidents caused by operating out of the scope of the aerial device

• 8 hour course
• Analyzed forces acting on an Aerial Apparatus
RESOURCES

• NFPA 1901 & 1911

• Truck Company Operations
  • Mittendorf

• IFSTA Fire Department Aerial Apparatus
NFPA 1901
AERIAL DEVICE

• Consists of two or more ladder sections
  • To reach a minimum vertical height of 50 feet.
  • Rated at a minimum of 250 lbs.
    » Fully extended in a horizontal position.

• Full complement of ground ladders
  » Total 115 feet
  » At least 2 extension, 2 straight, and 1 attic
TYPES OF AERIALS

STRAIGHT LADDER ("STICK")

ELEVATED PLATFORM ("BOOM")

ELEVATED LADDER PLATFORM
AERIAL APPARATUS DESIGN

• CHASIS:
  • Main driving unit
  • Includes motor, breaking, electronics, etc.

• AERIAL:
  • Structure
  • Mechanics
  • Hydraulics
  • Electrical
AERIAL APPARATUS FAILURE

THREE CAUSES OF FAILURE:

1. Wear
2. Abuse / Overloading
3. Poor design / Manufacturing Flaw
APPARATUS STABILIZATION
CONSIDERATION #1

• While operating an aerial ladder at full extension and a 45 degree angle, the outriggers on the opposite side come off the ground.

• Do you continue working?
STABILITY

“The truck is considered to be in a state of stability when no sign of overturning is evident with the aerial ladder or elevating platform in operation. The lifting of a tire or stabilizer on the opposite side of the vehicle from the load does not necessarily indicate a condition of instability. Instability occurs when an aerial device can no longer support a given load and overturning is imminent.”
### OUTRIGGER FORCE TEST

**2003 KME TILLER TRUCK**

**100’ (4) SECTION STRAIGHT LADDER**

<table>
<thead>
<tr>
<th>Aerial Orientation</th>
<th>Driver’s Side Outrigger (lbs)</th>
<th>Passenger’s Side Outrigger (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ladder bedded</td>
<td>8500</td>
<td>8600</td>
</tr>
<tr>
<td>Elevated to 75 degrees</td>
<td>8800</td>
<td>9000</td>
</tr>
<tr>
<td>Fully extended at 75 degrees</td>
<td>9200</td>
<td>9600</td>
</tr>
<tr>
<td>Rotate to 90 degrees to truck</td>
<td>6700</td>
<td>12800</td>
</tr>
<tr>
<td>Lower angle to 60 degrees</td>
<td>2600</td>
<td>16500</td>
</tr>
<tr>
<td>45 degrees</td>
<td>200</td>
<td>19700</td>
</tr>
<tr>
<td>30 degrees</td>
<td>0- Lifted</td>
<td>22000</td>
</tr>
<tr>
<td>15 degrees</td>
<td>0- Lifted</td>
<td>24000</td>
</tr>
<tr>
<td>0 degrees</td>
<td>0- Lifted</td>
<td>24600</td>
</tr>
<tr>
<td>With a 200 lb load added to tip</td>
<td>0</td>
<td>25600</td>
</tr>
</tbody>
</table>
APPARATUS POSITIONING
APPARATUS POSITIONING

It is a good practice to drive past the incident location. This will allow the truck company officer a look at three sides of the building.

Considerations prior to spotting the ladder:
- Overhead hazards
- Collapse zones
- Width of the street
- Location of victims
- Height of the building
APPARATUS POSITIONING

Often spotting at the corner of the building is best.
- Closer than collapse zone
- Option of two sides of the building

If building is on a steep incline, a position on the downhill will maximize the angle; a position uphill will maximize the reach.
Elevated platforms should be placed with the bottom of the platform just above and over the roof edge.

Elevated platform rail should be placed even with the windowsill. Shoot above and work down.

Sraight “stick” ladders should extend past the roof-line for access from both sides. Roof ladders for parapets should be used.
CONSIDERATION #2

SUPPORTED V. UNSUPPORTED

SUPPORTED

UNSUPPORTED
AERIAL LOADS

NFPA 1901

• **Dead Load**: The weight of the aerial device structure and all materials, components, mechanisms, or equipment permanently fastened thereto.

• **Live Load**: Forces acting on the aerial device from personnel, portable equipment, water, and nozzle reaction.
AERIAL LOADS

• Rated Capacity: The total amount of weight of all personnel and equipment that can be safely supported at the outermost rung of an aerial ladder or on the platform of an elevating platform with the waterway uncharged.

• All structural load supporting elements of the aerial device that are made of a ductile material shall have a design stress of not more than 50 percent of the minimum yield strength of the material based on the combination of the rated capacity and the dead load.

• 2:1 Safety Factor
AERIAL LOADS

• Stress: applied force to an object
• Strain: how the object responds

• How are forces applied
  • Static (semi-static): Forces at rest or slowly applied
  • Dynamic (shock loads): Forces in motion or quickly applied
CONSIDERATION #3

APPLICATION OF LOADS:

Force = Mass X Acceleration

- Mass = 250 lb Firefighter
- Acceleration = 1 ft/sec (Dynamic/bouncing loads)
- Force = 500 N/lbs

- On a ladder rated at 250 lbs at the tip, with a 2:1 safety factor, with dynamic loads, we are at the limit.
LADDER CAPACITY CHART

• For ladders that are rated above 250 lbs, NFPA requires load charts:
AERIAL RESCUE

• Aerial Apparatus High Pick Point

• Uses:
  • Below grade rescue
    » Man hole
    » Over-the-side
  • High rise rescue
    » Roof Rescue
    » Window Rescue
AERIAL RESCUE

High Pick Point Anchor Loads

250 lbs

500 lb Force at the tip.

250 lbs

250 lbs

250 lbs

250 lbs

250 lbs
AERIAL RESCUE
LOAD DEGREES

500 LBS

467 LBS

30°

427 LBS

45°

250 lbs

250 lbs

250 lbs
HIGH PICK POINT

American LaFrance TDA (tractor drawn aerial)

• All personnel should be trained on proper rope rescue techniques

• Apparatus operator should communicate with other crew members what the rated tip loads are for the operating angle.
HIGH PICK POINT

• The aerial should only be used as a high pick point anchor

• The aerial should not be moved in any direction during rescue operations (up/down, rotate, extend, or retract).

• Mandated by the manufacture and OSHA
HIGH PICK POINT

• Mechanical advantage should be accomplished by rope pulled manually

• “Z-Rig” / “RPM”
  • 3:1

• “Ladder Rig”
  • 2:1
  • 4:1 - Must be positioned at 1000 lb rating
HIGH PICK POINT

- All rigging attempts shall be made off the sides of the turntable from 30% forward to the cab through 30% towards tiller trailer.
HIGH PICK POINT

EXAMPLES OF AERIAL SET UP

80 FEET EXTENSION
12 DEGREES ELEVATION
750 LB TIP LOAD ONLY (CANT USE 4TO 1 SYSTEM)

T-6

30 FEET ELEVATION
HIGH PICK POINT

EXAMPLES OF AERIAL SET UP

1000 LB TIP LOAD
4 TO 1 SYSTEM CAN BE USED IN THIS CONFIGURATION
HIGH PICK POINT

Orange webbing is used at the tip. It must be tied through both eye-lets using a redundant loop with the knot at the bottom.
HIGH PICK POINT

Grab the webbing where it comes across between the eye-lets and bring it down to the bottom where a carabineer is attached. Attach a high point change of direction pulley.
HIGH PICK POINT

The next connection to make is at the bottom side of the base section of the aerial. This cross brace is located approximately 5 feet from the turn table. Note its location in the center of ladder (Important).
HIGH PICK POINT

This picture shows the location of the base section beam and the rope installed on the pulleys.

Note the line is going straight down the aerial.
HIGH PICK POINT

This is the location of the third anchor for the third change of direction pulley. This is an orange webbing and is tied using the redundant loop.
HIGH PICK POINT

This picture shows the rope location of the third change of direction pulley, note the pulley should be just outside of the fender.
HIGH PICK POINT
HIGH PICK POINT
BELAY PROCEEDURES

• All loads, whenever possible, should be belayed. Using a TDA as a high point is no exception. The difference comes in forces applied in a dynamic situation (i.e. main line failure).

• Even the best belayer will have some slack in the belay rope. This slack, during a main line failure, translates into force. Aerial ladders are not designed to handle shock loads.

• Whenever possible the belay should be positioned to minimize swing, pendulum and/or drop of the rescue package AND minimize or eliminate force on the TDA.
Scenario #1: If the aerial was being used as a high point to remove a patient from the roof of a structure the aerial’s ladder should be positioned so that, when the patient is lowered, the litter is as close to the building as possible. The belay line should be attached to a suitable anchor on the roof of the structure and go directly over the edge of the building. In this scenario the belay line is never attached to the aerial.
Scenario #2: A below grade vault, manhole, etc. Once again green is the main and red is the belay. Again note that the belay is independent of the aerial. It is also worth noting that the patient should only be lifted high enough to clear the hole. Once the belay is above the level of the hole, main line failure will result in a large dynamic event.
HIGH PICK POINT
BELAY PROCEEDURES

• When selecting any belay anchor you must remember that the load will be
dynamic (falling due to main line failure).

• A one foot drop can magnify 5 -7 times its force on the anchor depending
on the length of the drop.

• Due to the angle the rope forms at the top of the aerial, the load can be as
high as twice the load at the tip of the aerial. Due to the forces created it is
recommended that when running the belay along the aerial that the aerial
should be as closed to a climbing angle (70 degrees) as possible. This
configuration loads the rams not the ladder itself.
HIGH PICK POINT
BELAY PROCEEDURES

• If there are no other options and the aerial must be used as a belay track, the belay line should be run along the top of the aerial, over the tip, across the built in rope roller and down to the load.

• Using the aerial as a high point belay should be considered a last option. The forces created can easily exceed the manufactures recommendation. Only as a last resort should the belay be run along the aerial ladder.