

# Introduction and Overview of Aerial Lift Testing Per ANSI 92.2-2015 Standards

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# What should you reference for dielectric testing your Bucket Trucks and Aerial Lifts

- ANSI 92.2-2009
- The lift manufacturer
- Your own best high voltage safety practices



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# Special Note

- This presentation is not meant to be an interpretation of the ANSI 92.2-2009 and previous ANSI 92.2 Standards
- These standards have been worded to be open to interpretation of the reader
- Some slides quote the ANSI 92.2-2009 Standard directly
- This PowerPoint covers portions from;
  - Section 5.4.2
  - Section 5.4.3
  - Table 1
  - Table 2
  - Table 3



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# What is the Purpose of ANSI 92.2-2009?

Per section 1.2 of ANSI 92.2:

“This standard applies to the establishment of criteria for design, manufacture, testing, inspection, installation, maintenance, use, training, and operation of vehicle-mounted aerial devices, primarily used to position personnel, installed on a chassis to achieve the following objectives:

1. Prevention of personal injuries and accidents.
2. Uniformity in ratings.
3. Understanding by manufacturers, dealers, installers, maintenance personnel, operators, owners, and users of their respective responsibilities.”



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# Important Things To Note While Testing

- Category of the aerial lift: A, B, or C
- Test to be conducted
  - Qualification Test
    - Used for new or after repairs involving the insulating path
    - Uses Table 1
  - Periodic Test
    - Uses Table 2 or Table 3
- Boom orientation for consistency and duplication of test results
- Stability of leakage current readings where applicable



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# Testing the boom on a new truck – The Qualification Test



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# Section 5.4.2.1 Test Procedures for Category A & B Aerial Devices

- The boom should be positioned;
  - a) With lower boom vertical and upper boom extended at 90 degrees per Figure 2
  - b) Single boom at 45 degrees and extended to minimum extension required by manufacturer per Figure 5
- The test voltage and duration criteria from Table 1 for Category A & B should be followed
  1. One minute 60 Hz Rated Voltage Test (kV rms)
  2. One minute 60 Hz Double-Rated Voltage Test (kV rms)
  3. Either;
    - a) 60 Hz Momentary Withstand Voltage Test (kV rms)
    - b) Switching Surge Withstand Voltage Test (kV crest)
- The current value for the rated voltage should be documented



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Table 1 from ANSI92.2-2009

Design, Quality Assurance and Qualification Test Values for Insulating Aerial Devices  
 Insulating Aerial Devices with a Lower Test Electrode System  
 (Category A and Category B)

Unit Rating	Required 60 Hz Rated Voltage Test		Required 60 Hz Double-Rated Voltage Test		Either of These Withstand Tests	
Rated Line Voltage (rms kV)	One Minute Test Voltage (rms kV)	Maximum Allowable Boom Current (rms microamperes)	One Minute Test Voltage (rms kV)	Maximum Allowable Boom Current (rms microamperes)	60 Hz Momentary Withstand Voltage Test (rms kV)	Switching Surge Withstand Voltage Test (crest kV)
46 & Below	27	27	54	54	80	114
69	40	40	80	80	120	170
138	80	80	160	160	240	340
230	133	133	265	265	400	565
345	200	200	400	400	600	850
500	288	288	575	575	720	1020
765	442	442	885	885	1105	1560



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# Section 5.4.2.2 Test Procedures for Category C Aerial Devices

- The boom should be positioned;
  - a) With lower boom vertical and upper boom extended at 90 degrees per Figure 3
  - b) Single boom at 45 degrees and extended to minimum extension required by manufacturer per Figure 5
- The test voltage and duration criteria from Table 1 for Category C should be followed
- The current value for the rated voltage should be documented



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Table 1 from ANSI92.2-2009  
 Design, Quality Assurance and Qualification Test Values for Insulating Aerial Devices  
 Insulating Aerial Devices without a Lower Test Electrode System  
 (Category C)

Unit	60 Hz	Maximum Allowable	Time of
Rating	Voltage	Current	Test
46 kV	100 kV (rms)	1 milliampere (rms)	3 minutes



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# Testing the boom on an existing truck – The Periodic Test



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# Section 5.4.3.1 Test Procedures for Category A & B Aerial Devices

- The boom should be positioned;
  - a) With lower boom vertical and upper boom extended at 90 degrees per Figure 2
  - b) Single boom at 45 degrees and extended to minimum extension required by manufacturer per Figure 5
- The test voltage and duration criteria from Table 2 for Category A & B should be followed
  - 4 Test Methods Available
    - a) A 60 Hz Test Voltage as shown in Table 2
    - b) A Direct Current Test Voltage as shown in Table 2
    - c) Field test raising boom to HV line and recording leakage current not to exceed values in Table 3
    - d) Field test with fused, protected, and shielded ammeter between the boom and HV line recording leakage current not to exceed values in Table 3
- The current value for the rated voltage should be documented



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**Table 2**  
**Periodic Electrical Test Values for Insulating Aerial Devices**  
**Insulating Aerial Devices with a Lower Test Electrode System**  
**(Category A and Category B)**

Unit Rating	60 Hz (rms) Test			Direct Current Test		
	Voltage	Maximum Allowable Current	Time	Voltage	Maximum Allowable Current	Time
46 & Below	40 kV (rms)	40 microamperes	1 minute	56 kV	28 microamperes	3 minutes
69	60 kV (rms)	60 microamperes	1 minute	84 kV	42 microamperes	3 minutes
138	120 kV (rms)	120 microamperes	1 minute	168 kV	84 microamperes	3 minutes
230	200 kV (rms)	200 microamperes	1 minute	280 kV	140 microamperes	3 minutes
345	300 kV (rms)	300 microamperes	1 minute	420 kV	210 microamperes	3 minutes
500	430 kV (rms)	430 microamperes	1 minute	602 kV	301 microamperes	3 minutes
765	660 kV (rms)	660 microamperes	1 minute	924 kV	462 microamperes	3 minutes



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## Section 5.4.3.1 Test Option C Explained Further

“In the field and with the vehicle grounded the insulated boom may be raised into a high voltage line whose voltage is as high or higher than the voltage to be worked, but not to exceed the Qualification Voltage of the aerial lift unit. Current shall not exceed values as shown in Table 3. This test shall be performed on a frequent basis to meet the Periodic Test requirement.”



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# Table 3

## In-Field Tests for Insulating Aerial Devices

### Method Called Out In Section 5.4.3.1 Item 10(c)

Aerial Device Category	A. C. Voltage	Maximum Allowable Current	Time of Test
A or B	Line to Ground	1 milliamperes/kV AC	3 minutes
A or B	Line to Ground	0.5 microamperes/kV AC	3 minutes



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# Section 5.4.3.1 Test Option D Explained Further

“In the field and with the vehicle grounded, a fused and protected ammeter shall be placed between the high voltage line and the bonded metal fitting at the platform. A shunting arrangement shall be used while engaging or disengaging from the power line. (This test may be used as the Periodic Test when the voltage is at least double that of any circuit on which the aerial device is to be used, but not exceeding the Qualification Voltage of the aerial device).

The ammeter should be shielded from any stray electrical currents, and should give the measurement of any leakage current across the boom and controls, or any capacitive currents involved from the platform to ground, or both. The minimum voltage of the test line should be that of any circuit on which the aerial device is to be used. Current shall not exceed values as shown in Table 3. This test shall be performed on a frequent basis to meet the Periodic Test requirement.”



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# Table 3

## Method Called Out in Section 5.4.3.1 Item 10(d) & Section 5.4.3.2 Item 5(c)

Aerial Device Category	A. C. Voltage	Maximum Allowable Current	Time of Test
All Insulating Aerial Devices	Line to Ground	30 microamperes/kV AC	3 minutes



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# Section 5.4.3.2 Test Procedures for Category C Aerial Devices

- The boom should be positioned;
  - a) With lower boom vertical and upper boom extended at 90 degrees per Figure 3 or 3A
  - b) Single boom at 45 degrees and extended to minimum extension required by manufacturer per Figure 5
- The test voltage and duration criteria from Table 2 or 3 for Category C should be followed
  - a) A 60 Hz Test Voltage as shown in Table 2
  - b) A Direct Current Test Voltage as shown in Table 2
    - Figure 3A shows an alternate test with the current meter of the Hipot on the high side instead of the low side of the aerial lift. This is a provision for DC hipots with high internal leakage current and/or no guard circuit.
  - c) Field test with fused, protected, and shielded ammeter between the boom and HV line recording leakage current not to exceed values in Table 3
- The current value for the rated voltage should be documented



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**Table 2**  
**Periodic Electrical Test Values for Insulating Aerial Devices**  
**Insulating Aerial Devices without a Lower Test Electrode System**  
**(Category C)**

Unit Rating	60 Hz (rms) Test			Direct Current Test		
	Voltage	Maximum Allowable Current	Time	Voltage	Maximum Allowable Current	Time
46 & Below	40 kV (rms)	400 microamperes	1 minute	56 kV	56 microamperes	3 minutes



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## Section 5.4.3.2 Test Option C Explained Further

“In the field and with the vehicle grounded, a fused and protected ammeter shall be placed between the high voltage line and the bonded metal fitting at the platform. A shunting arrangement shall be used while engaging or disengaging from the power line.

The ammeter should be shielded from any stray electrical currents, and should give the measurement of any leakage current across the boom and controls, or any capacitive currents involved from the platform to ground, or both. The minimum voltage of the test line should be that of any circuit on which the aerial device is to be used. Current shall not exceed values as shown in Table 3. This test shall be performed on a frequent basis to meet the Periodic Test requirement. This test may be used as the Periodic Test when the voltage is at least double that of any circuit on which the aerial device is to be used, but not exceeding the Qualification Voltage of the aerial device.”



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# Table 3

## Method Called Out in Section 5.4.3.1 Item 10(d) & Section 5.4.3.2 Item 5(c)

Aerial Device Category	A. C. Voltage	Maximum Allowable Current	Time of Test
All Insulating Aerial Devices	Line to Ground	30 microamperes/kV AC	3 minutes



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# Typical Dielectric Test Setup

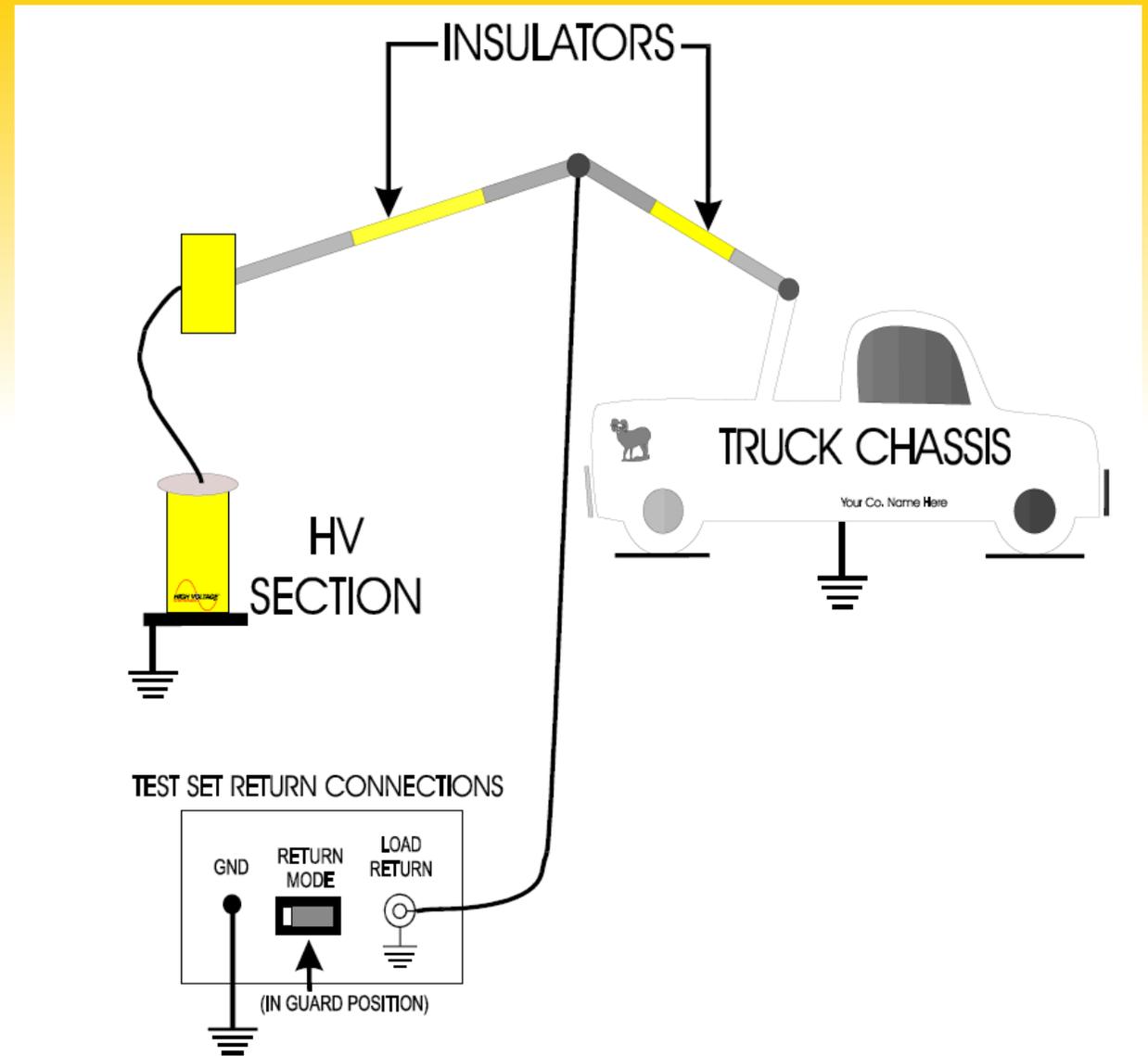


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# ANSI Test On Upper Insulated Arm of a Double Insulated Aerial Boom Truck



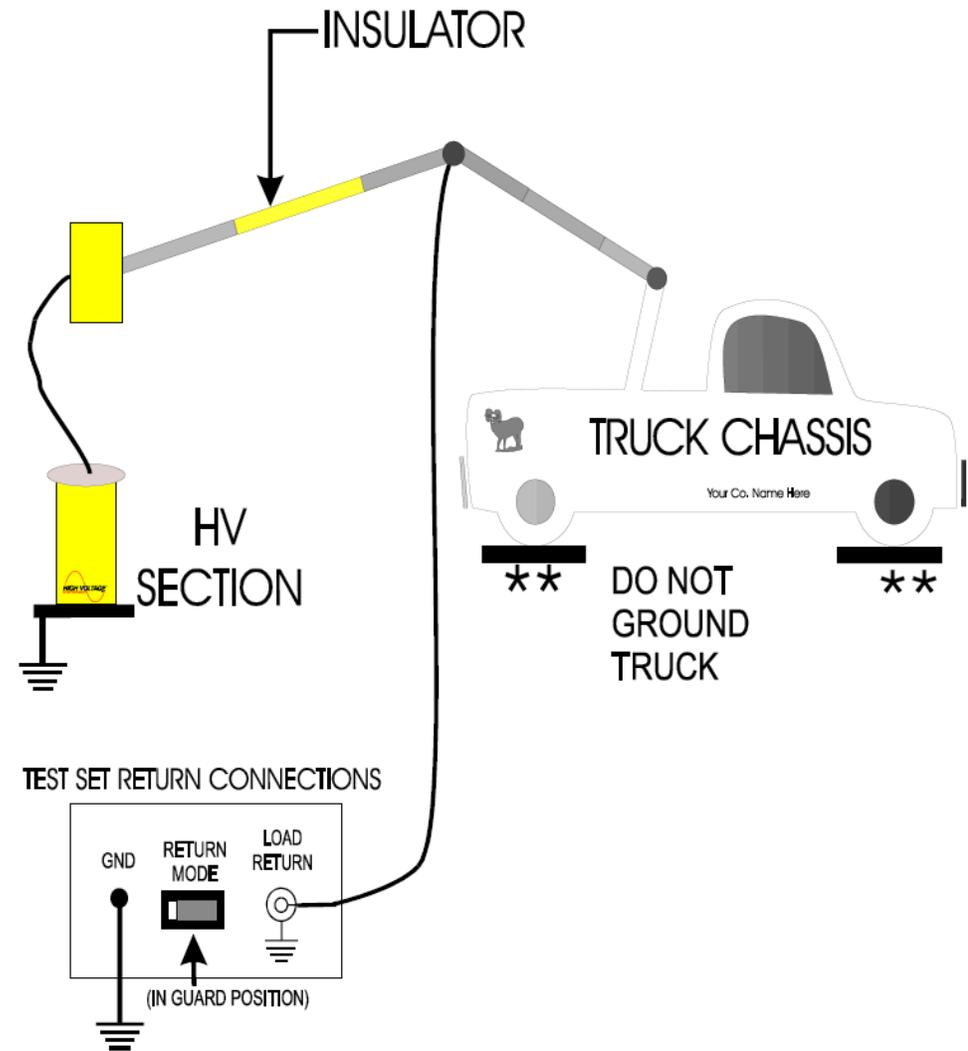
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# ANSI Test On Upper Insulated Arm of a Single Insulated Aerial Boom Truck

\*\* Insulator Pads May Be Needed. Damage Mat Result To Tires If Pads Are Not Used

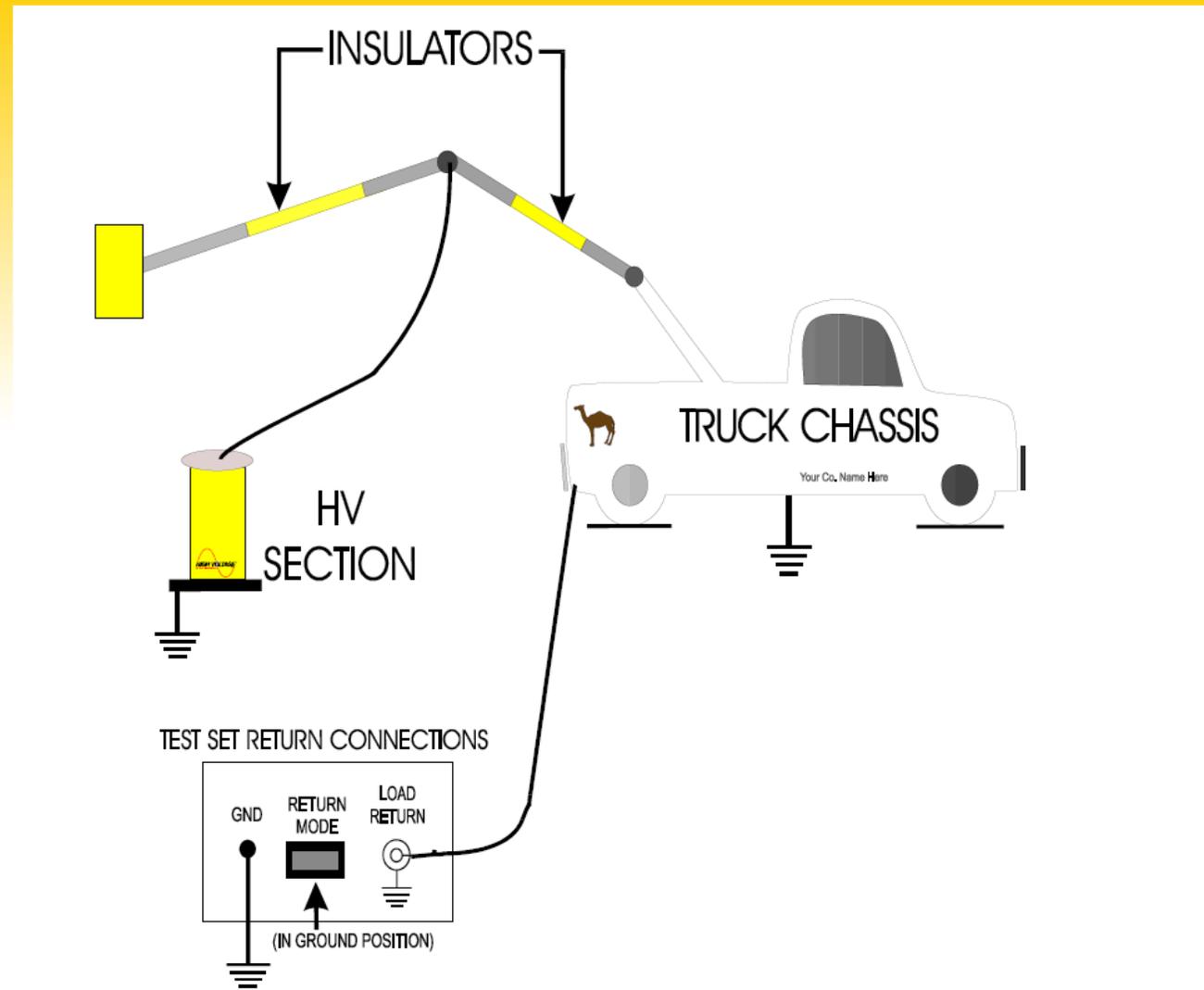


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# Flash Over Test on Lower Insulated Arm of a Double Insulated Aerial Boom Truck



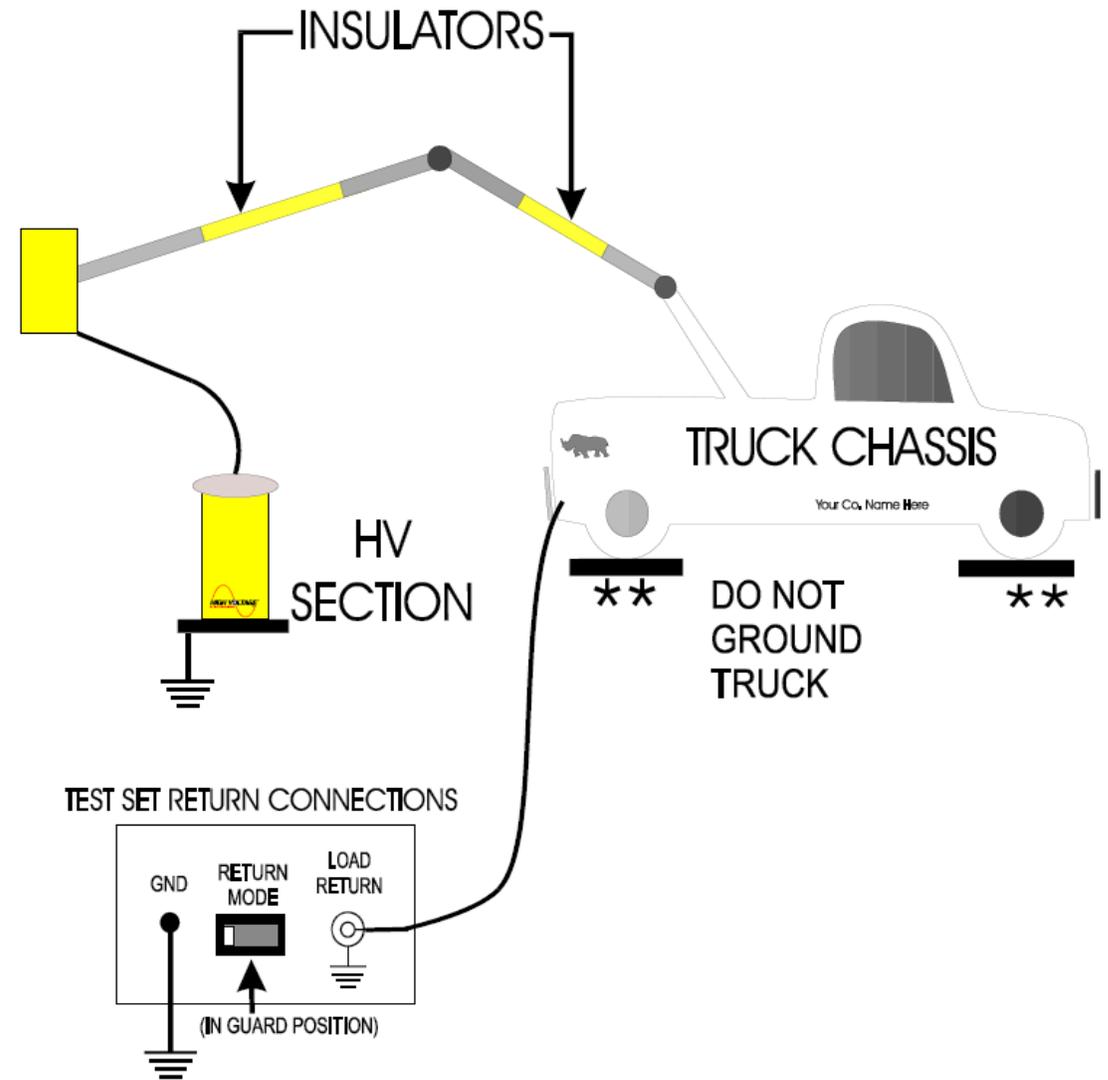
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# Overall Test On a Double Insulated Aerial Boom Truck

\*\* Insulator Pads May Be Needed. Damage Mat Result To Tires If Pads Are Not Used



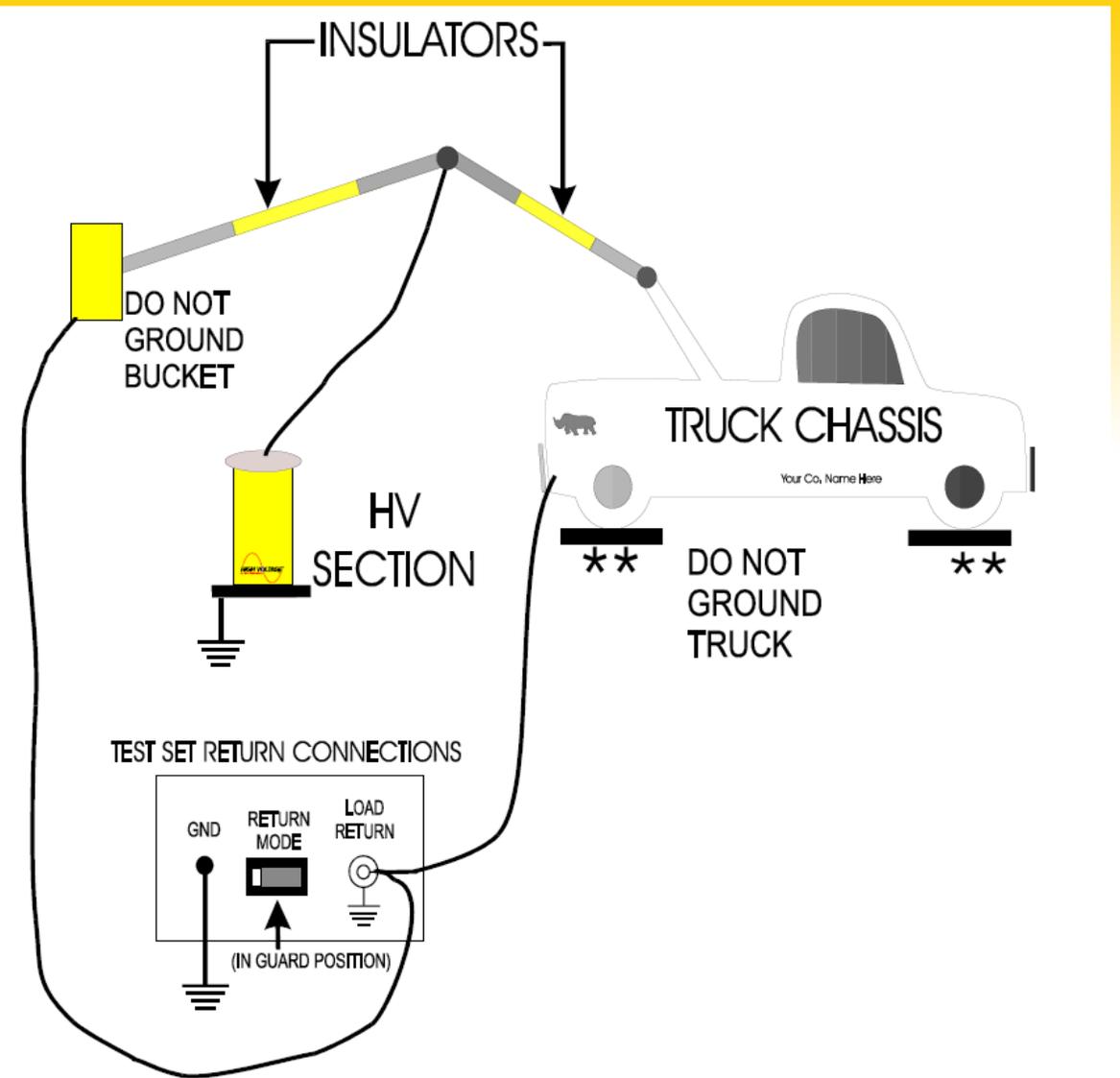
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# Phase to Phase Test of Double Insulated Aerial Boom Truck

\*\* Insulator Pads May Be Needed. Damage Mat Result To Tires If Pads Are Not Used



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# Bucket Liner Testing – Qualification Test



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# Bucket Liner Testing Per ANSI 92.2

## Section 5.4.2.5 Qualification Test procedures for Insulating Liners

“Platform liners used for insulation shall be tested in a conductive liquid. The liquid level around both the inner and outer surfaces of the liner shall be within 6 inches (152 mm) of the top of the liner. The liner shall withstand a minimum of 50 kV 60 Hz for 1 minute without flashover or breakdown through the material.”



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# Bucket Liner Testing – Periodic Test



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# Bucket Liner Testing Per ANSI 92.2

## Section 5.4.3.5 Periodic/Maintenance Test Procedures for Insulating Liners

### Option 1

“Platform liners used for insulation shall be tested in a conductive liquid. The liquid level around both the inner and outer surfaces of the liner shall be within 6 inches (152 mm) of the top of the liner. The liner shall withstand a minimum of 35 kV 60 Hz for 1 minute or 100 kV DC for 3 minutes without flashover or breakdown through the material.”



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# Bucket Liner Testing Per ANSI 92.2

## Section 5.4.3.5 Periodic/Maintenance Test Procedures for Insulating Liners

### Option 2

“The entire surface inside and outside to within 6 inches (152 mm) of the top of the liner may be tested using other conductive electrodes such as wet cellulose sponge, wet cloth towels, or metal foil. The electrodes shall adhere closely to the inside and outside surface. Each side and the bottom of the liner may be tested one surface at a time if the procedure ensures that the area in all corners is tested. (For testing the bottom of the liner, the user may find it easier to use a mix of electrode materials such as a conductive liquid for the inside electrode and a wet cellulose sponge, wet cloth towels, or metal foil for the outside electrode).

The liner shall withstand a minimum of 35 kV 60 Hz for 1 minute, or 100 kV DC for 3 minutes without flashover or puncture of liner wall.”

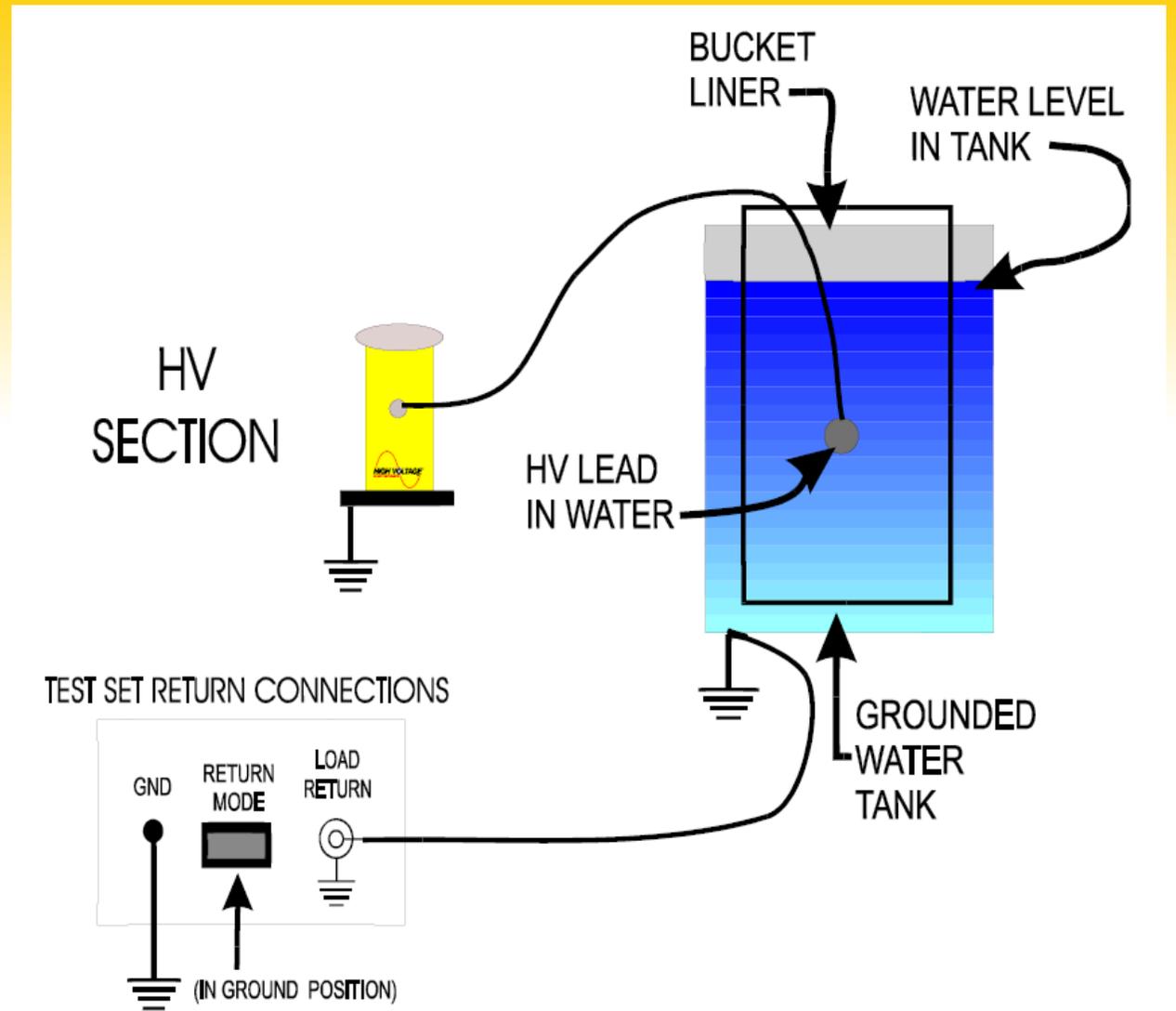


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# Flash Over Test On Bucket Liner In Water



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# What type of Hipot?

2 Options

AC



DC



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# Voltage Sources: AC

## Pros

- Same wave shape and frequency of service condition
- Required as the factory qualification test
- Required as re-qualification after a repair in the insulation path
- Matches the factory qualification test (field use)
- Shorter test duration than DC (1 minute vs 3 minutes)

## Cons

- Larger and heavier than DC
- More expensive than DC
- No shielded HV output cable



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# Voltage Sources: DC

## Pros

- Smaller and lighter than AC
- More cost effective than AC
- Shielded HV output cable

## Cons

- Does not match the service condition
- Does not match the factory qualification tests
- Longer test duration when compared to AC (3 minutes vs 1 minute)



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# Required Hipot Features

- Accurate Voltmeter (multi-range if analog)
- Accurate Current Meter (multi-range if analog)
  - Grounded/Guarded Return Circuit
  - Portable Design (If Field Testing)
    - Overload Safety Circuit
  - Flexible Shielded Output Cable (DC Only)
- Automatic Power Supply Grounding With HV Off (DC Only)



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# Guard Circuit

What is a Guard Circuit?

A guard circuit is part of the current meter circuit designed to allow stray leakage currents to bypass the current meter when desired.



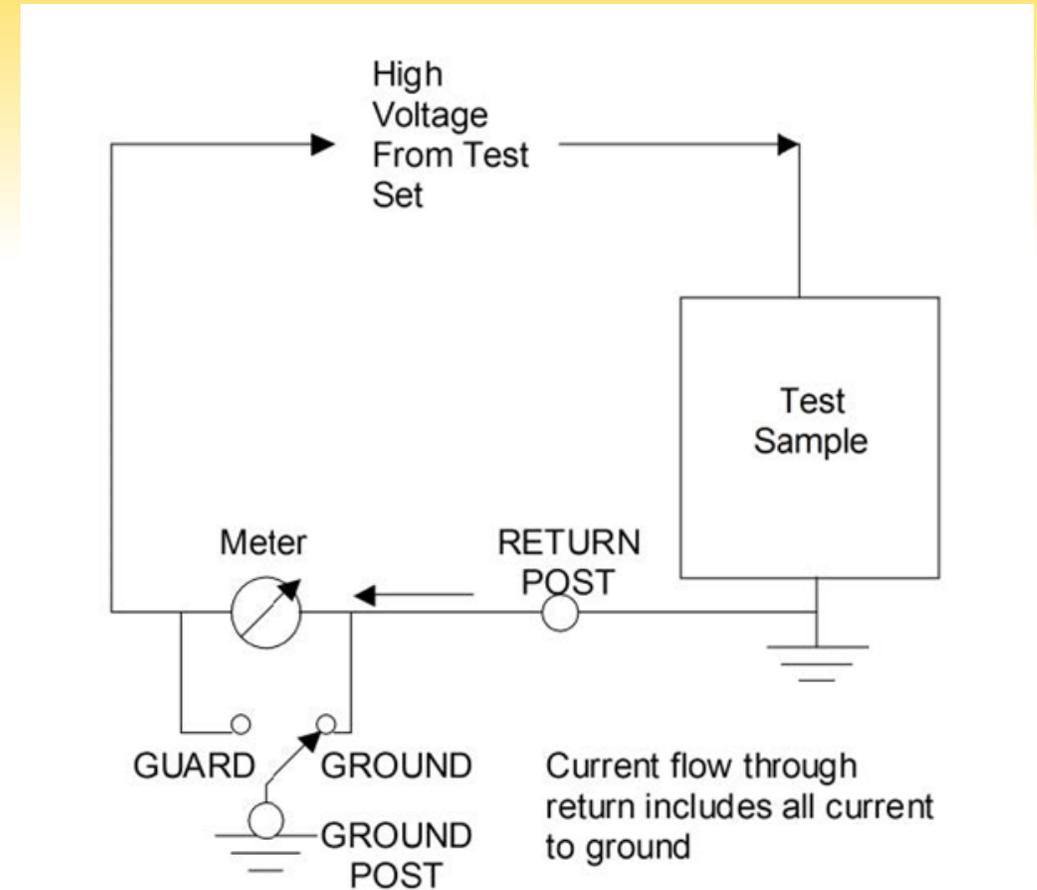
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# Grounded Return

- All Leakage currents to ground will flow through the current meter
- These currents include the internal leakage current within the high voltage power supply, shielded output cable, and any other leakage currents to ground.
- Mainly used when the low side of the test object is at ground potential or when leakage current measurements are not that critical



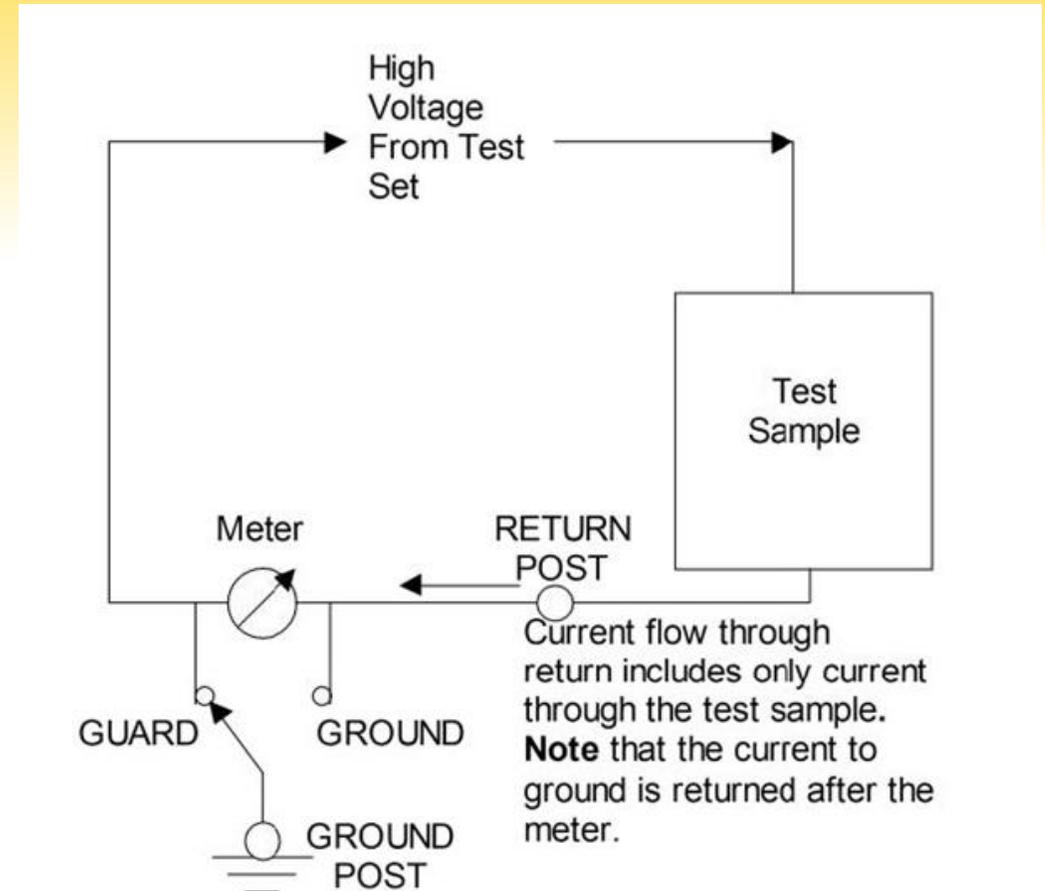
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# Guarded Return

- Used to measure leakage current through the test object only.
- This permits accurate reading of leakage currents through only the insulation area desired.
- The low side of the test load (return wire connection) must be insulated from ground.
- All stray leakage currents to ground are not indicated on the current meter



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# Why Does an AC Hipot Not Come With an Output Cable?

- Shielded output cables are a capacitive load to the hipot
  - Current draw can exceed the capabilities of the hipot
- At 100kV+ shielded output cables become too unwieldy
  - Too large in diameter
  - Too heavy to be practical



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# Field Demo with High Voltage, Inc. PTS-100U



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# Main Features of PTS-100U

- 100kV DC Hipot
- 2 Piece Modular Design
- 50ft Shielded Output Cable
- 2 Range Voltmeter
  - High (0-100kV DC) and Low (0-50kV DC)
- 5 Range Current Meter
  - 0-10mA, 0-1mA, 0-100uA, 0-10uA, and 0-1uA
- Guard Circuit in High Voltage Return Circuit



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Thank you from  
the team at



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