

ANSI/ESD S6.1-2005

ESD Association Standard

*ANSI/ESD S6.1-2005
Revision of ANSI/ESD S6.1-1999*

*For the Protection of Electrostatic
Discharge Susceptible Items*

Grounding



*Electrostatic Discharge Association
7900 Turin Road, Bldg. 3
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An American National Standard
Approved June 29, 2005

***ESD Association Standard for
the Protection of Electrostatic Discharge Susceptible Items -
Grounding***

Approved June 12, 2005
ESD Association



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Foreword

The single most important concept in the field of static control is grounding. Attaching all electrically conductive and dissipative items in the workplace to ground allows built-up electrostatic charges to equalize with ground potential. A grounded conductor cannot hold a static charge.

Electrically interconnecting all electrically conductive and dissipative items (bonding) allows charge to equalize across these items without actual contact to ground. This provides static control in areas where ground may not be accessible, such as in a field service environment. Electrically bonded conductors and dissipative items share stored electrical charge and therefore have no difference in electrical potential between them. Electrostatic Discharge (ESD) susceptible parts can be handled within a bonded system without causing damage.

Grounding of conductors for static control purposes may not provide sufficient grounding for Electromagnetic Interference (EMI) reduction or control. Low impedance electrical connections are required for EMI grounding and bonding while static grounding can be accomplished with relatively high resistance in connection points as well as along the discharge path.

This standard was originally approved on September 24, 1991 and was designated EOS/ESD-S6.1-1991. The original release was then reaffirmed and redesignated ANSI/ESD S6.1-1999 and approved on May 16, 1999 by the ESD Association Standards Committee. This standard is a revision of ANSI/ESD S6.1-1999. This Standard was prepared by the 6.0 Grounding Subcommittee. At the time, the 6.0 Grounding Subcommittee had the following members:

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ESD Association Standard

For the Protection of Electrostatic Discharge Susceptible Items – Grounding

1.0 PURPOSE & SCOPE

1.1 Purpose

This standard specifies the parameters, materials, equipment and test procedures necessary to choose, establish, verify and maintain an Electrostatic Discharge (ESD) Control grounding system for use within an ESD Protected Area (EPA) for protection of ESD susceptible items. This Standard also specifies the criteria for establishing ESD Bonding for protection of ESD susceptible items in field service or other remote operations.

1.2 Scope

This standard applies to bonding and grounding for the prevention of ESD in an EPA. The procedures, materials and techniques specified in this standard may not be applicable for grounding of electrical sources operating at frequencies above 400 Hz.

1.2.1 Applicability

Electrically initiated explosive devices and hazardous areas with flammable atmospheres may require additional considerations and are not covered by these requirements.

2.0 NORMATIVE REFERENCES

ESD ADV 1.0 – Glossary of Terms

ANSI/NFPA 70 – National Electrical Code

3.0 DEFINITIONS

Terms used in this document are in accordance with the definitions found in ESD ADV1.0 Glossary of Terms.

AC Equipment Ground

- a) The ground point at which the equipment grounding conductor is bonded to any piece of equipment, at the equipment end of the

conductor in a single-phase 120VAC electrical service.

- b) The 3rd wire (green/green with yellow stripe) terminal of a receptacle

Note: Wiring colors may vary by National Electrical Code.

- c) The entire low impedance path (electrically equivalent to the equipment grounding conductor) from a piece of electrical equipment to the neutral bus at the main service equipment.

Auxiliary Ground: A separate supplemental grounding conductor for use other than general equipment grounding.

Bonding Conductor: The wire, strap, flange or other electrically conductive mechanical device used to interconnect two otherwise isolated conductive or dissipative items.

Common Connection Point: A device or location (less than 1 ohm within itself) where the conductors of two or more ESD technical elements are connected in order to bring the **ungrounded** ESD technical elements to the same electrical potential through equipotential bonding.

Common Point Ground: A **grounded** device or location where the conductors of one or more technical elements are bonded.

Earth Grounding Electrode: The metal rod, metal plate, metal pipe, metal mesh, metal underground water pipe, or grounded metal building frame that are bonded to the neutral bus at the main service entrance.

ESD Grounding/Bonding Reference Point: The ESD grounding system selected for use in a facility or situation that best suits the application.

- a) AC equipment ground
- b) Auxiliary ground
- c) Equipotential bonding

ESD Technical Elements: All of the items, materials, devices, tools and equipment

used within an EPA for the control of static electricity.

Equipment Grounding Conductor: The conductor used to connect the non-current carrying metal parts of equipment, raceways and other enclosures to the main service equipment ground bus.

Equipotential: Having the same electrical potential; of uniform electrical potential throughout.

Grounding Electrode Conductor: A conductor used to connect the ground electrode(s) to the equipment grounding conductor, to the grounded conductor, or to both at the main service, at each building or structure where supplied from a common service, or at the source of a separately derived system.

Level 2 Technical Elements: Any ESD technical element that is connected in series to common point ground or to a common connection point through another technical element.

Isolated Ground: A separate equipment grounding conductor, which is only bonded to the ground bus (at the main service equipment) and a receptacle. It is permitted to pass through electrical panels, junction boxes etc., without being bonded to the equipment grounding conductor which services those devices. An isolated ground is not to be used to derive an ESD ground.

Isolated Ground Receptacle: A special electrical outlet that contains a separate equipment grounding conductor. The electrical receptacle is usually orange in color and has a colored triangle marked on the face of the receptacle. See Figure 4.

4.0 PERSONNEL SAFETY

The procedures and equipment described in this document may expose personnel to hazardous electrical conditions. Users of this document are responsible for selecting equipment that complies with applicable laws, regulatory codes and both internal and external company policy. Users are cautioned that this document cannot replace any requirements for personnel safety.

Ground fault circuit interrupters (GFCI) and other safety protection should be considered wherever personnel might come into contact with electrical sources. Electrical hazard reduction practices should be exercised and proper grounding instructions for equipment must be followed.

5.0 TECHNICAL REQUIREMENTS

All of the ESD technical elements used in the EPA shall be connected to the selected ESD grounding/bonding reference point.

5.1 ESD Grounding/Bonding Reference Point

The application and the physical environment will dictate the choice of the actual grounding system that will provide the best overall ESD protective system. The user of this document must select from the following systems in order to establish the ESD grounding /bonding reference point (see paragraph 5.1.1, 5.1.2, and 5.1.3).

5.1.1 AC Equipment Ground

Within an EPA, the AC equipment ground is the preferred ground when available. The equipment grounding conductor electrically bonds the AC equipment ground to the ground bus at the main service equipment panel of the facility. AC equipment within the EPA and all of the ESD technical elements will be at or near the same electrical potential when this system is used. See Figure 1, Figure 1A, Figure 5 and Figure 6.

5.1.2 Auxiliary Ground

Some facilities require the use of a separate or supplemental ground system. When this is the case, the auxiliary ground shall be bonded to the AC equipment ground when possible. In the event that it is not possible to electrically bond the two ground systems, it should be noted that AC equipment and the ESD technical elements might be at significantly different electrical potentials. See Figure 2.

5.1.3 Equipotential Bonding

Electrically interconnecting all of the ESD technical elements, the personnel within the

work area, and the equipment under service, equalizes electrical charges between the items to allow safe handling of ESD susceptible items. See Figure 3.

5.2 Connections to the ESD Grounding/Bonding Reference Point

All ESD technical elements used in the EPA must be electrically connected to the selected ESD grounding/bonding reference point.

5.2.1 Common Point Ground

All of the grounding conductors from each of the ESD technical elements (excluding level 2 technical elements) used within an EPA shall be terminated at the same electrically equivalent point. The common point ground may be a terminal strip, bus bar or any other convenient configuration that is, within itself, electrically continuous to no greater than 1 ohm measured from point to point with an ohmmeter as specified in paragraph 6.1.1. See Figure 1, Figure 1A and Figure 1B.

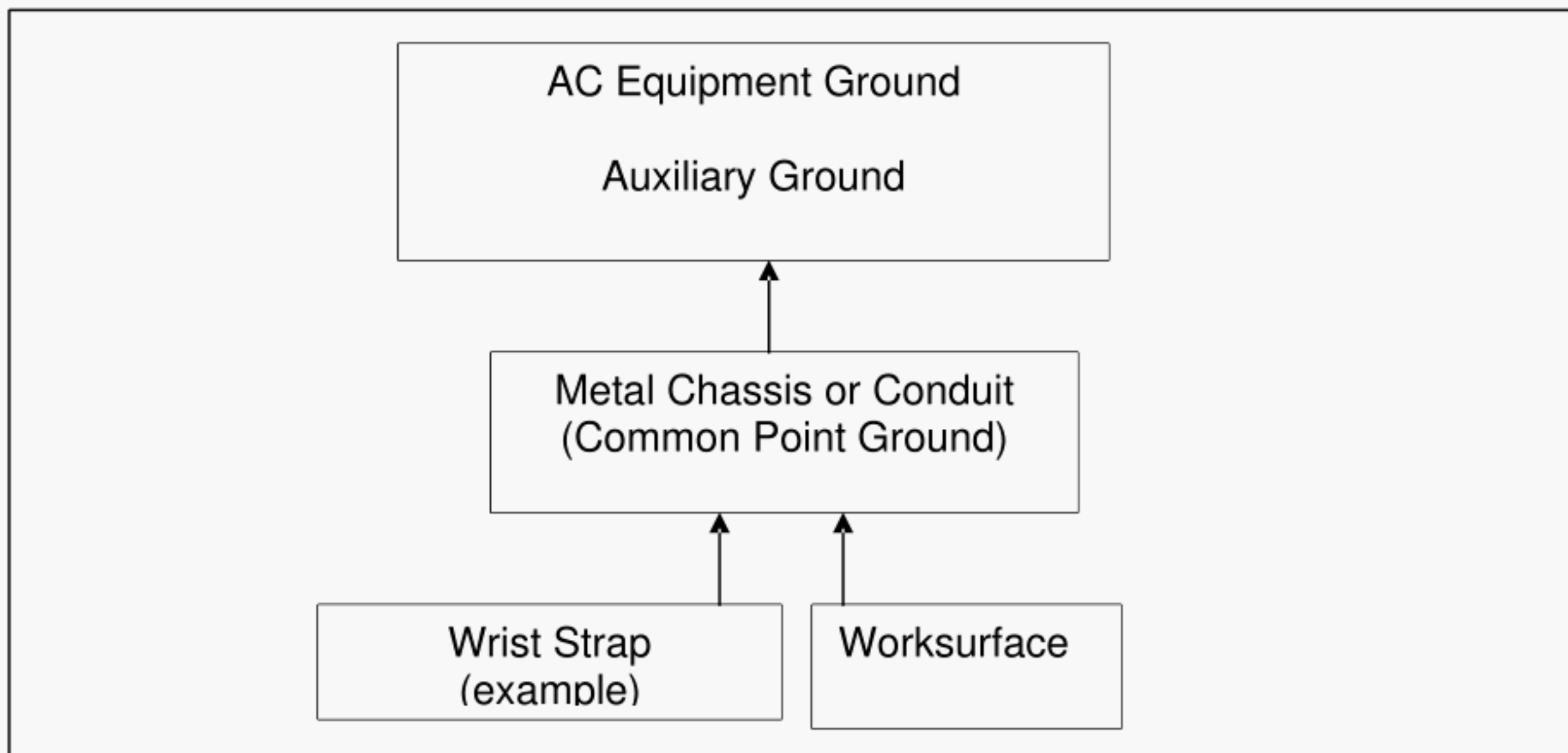


Figure 1 - Common Point Ground Concept (Simple)

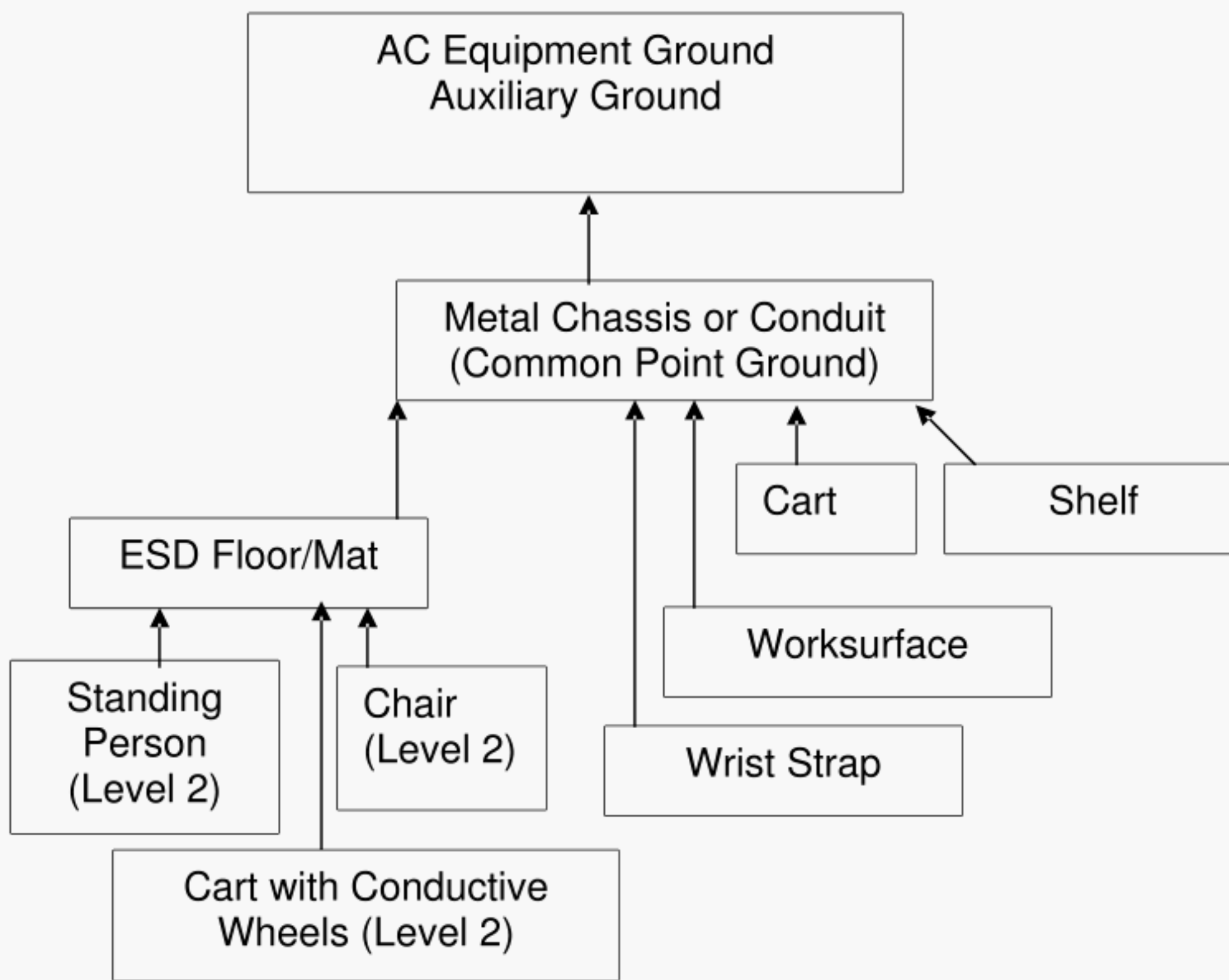


Figure 1A – Basic EPA Grounding System with Common Point Ground

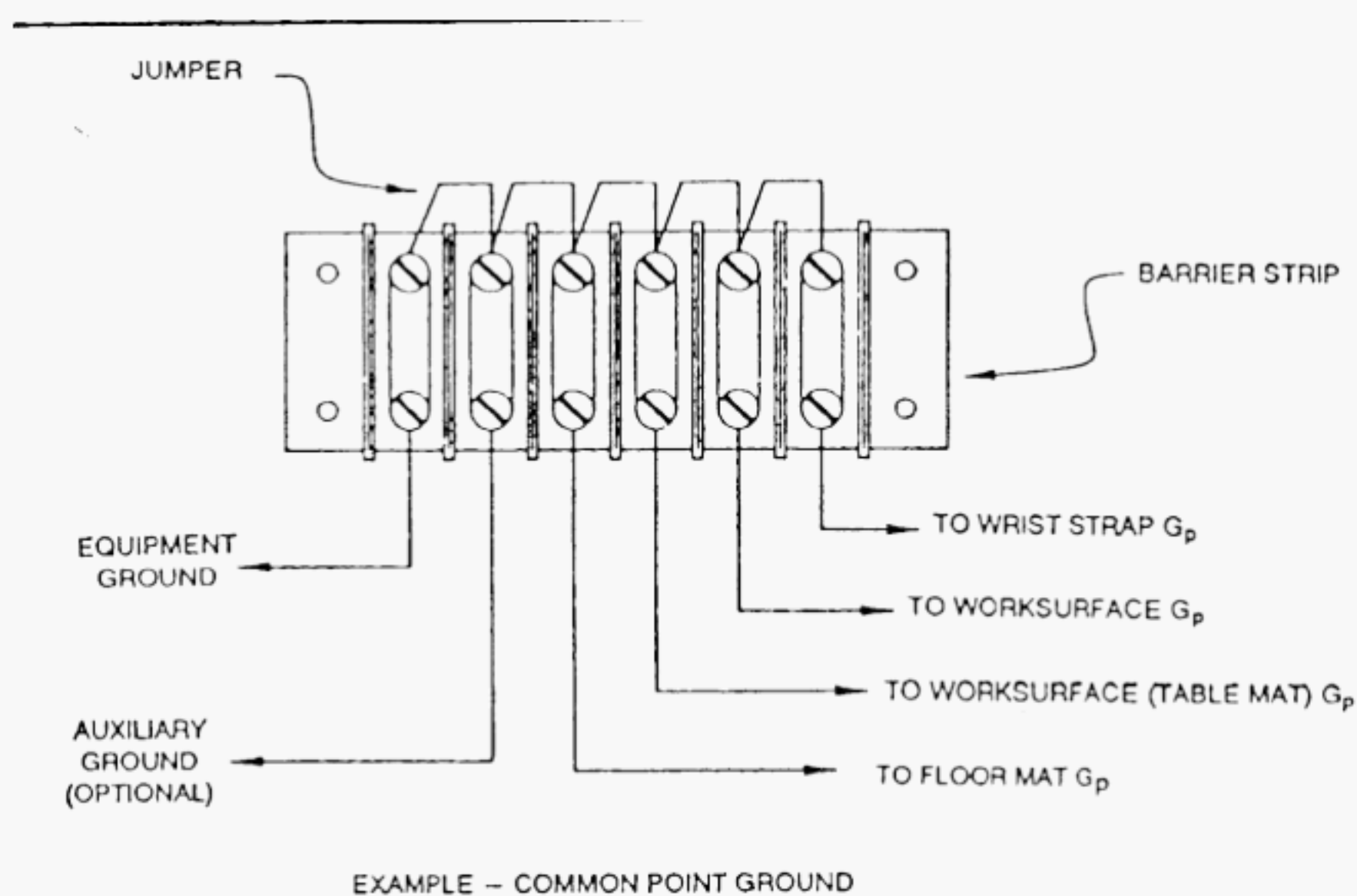


Figure 1B – Common Point Ground (example only)(G_p : Groundable Point)

5.2.2 Auxiliary Ground System

An auxiliary ground should be bonded to the equipment ground to ensure that there is no difference in electrical potential between the two systems. See Figure 2

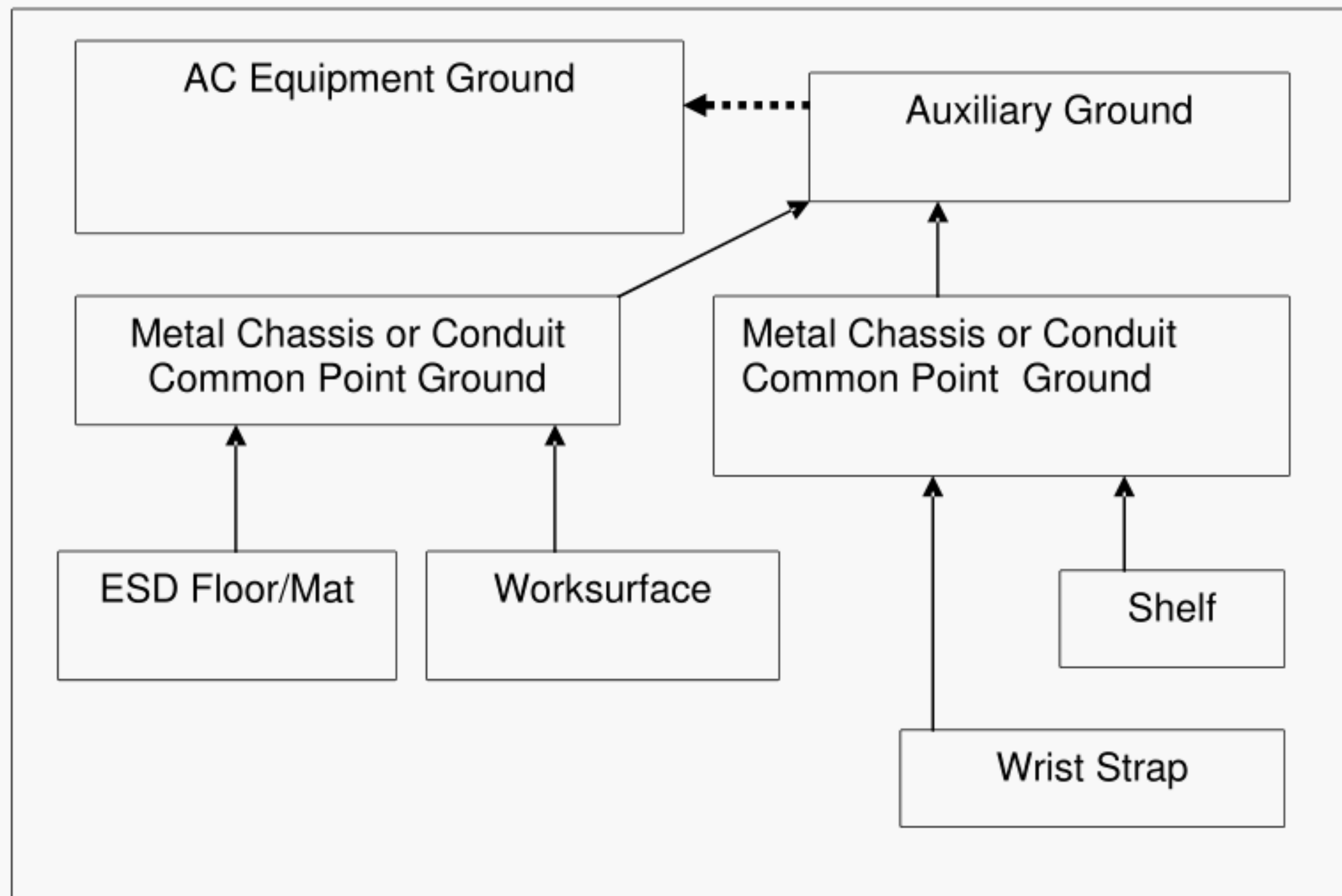


Figure 2 – Workstation with Two Common Point Grounds to an Auxiliary Ground

5.2.3 Equipotential Bonding

Field service operations and other ESDS handling situations may not have access to ground. Equipotential bonding provides an

ESD safe handling concept, as there is no difference in electrical potential between interconnected items. See Figure 3.

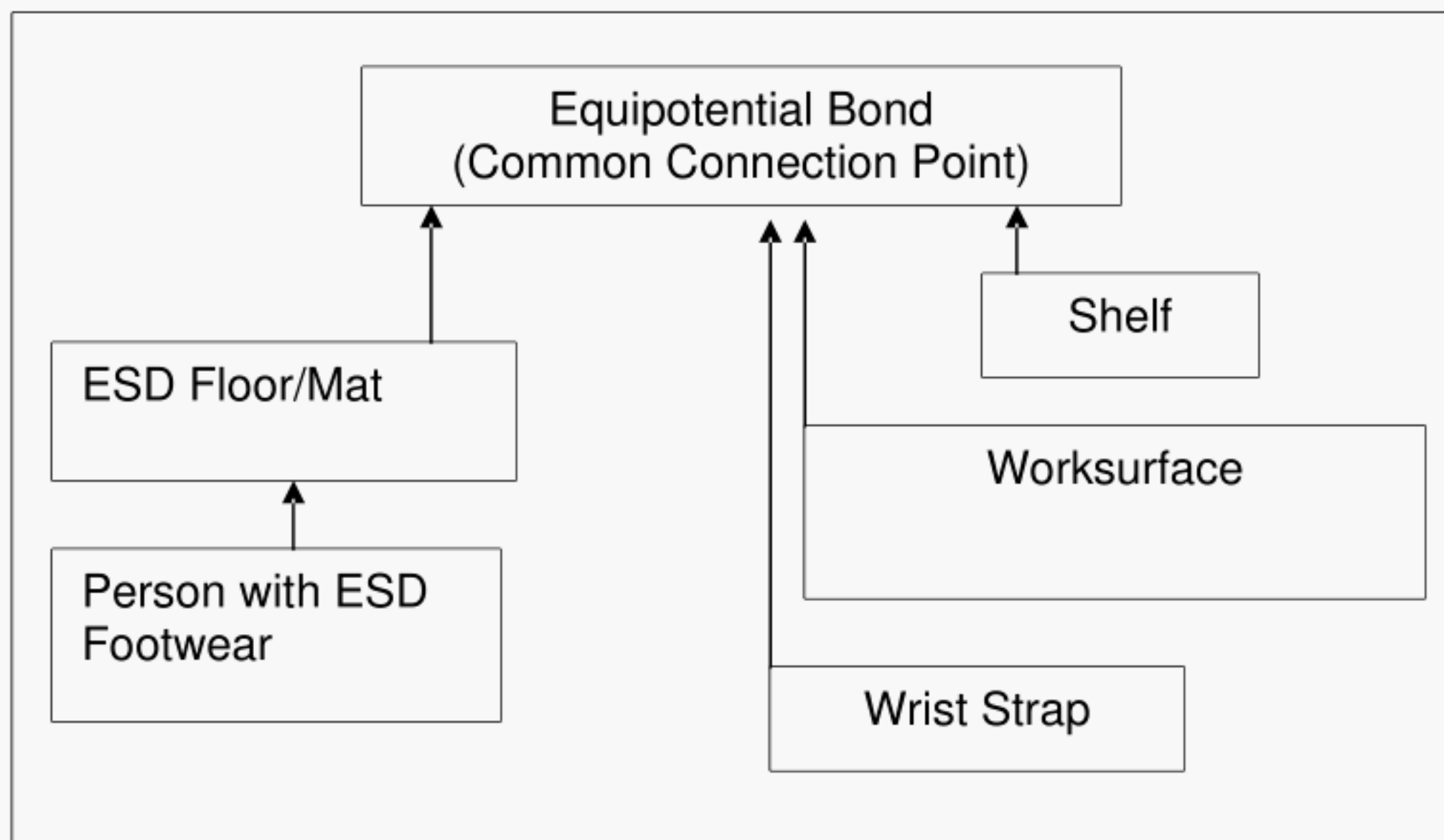


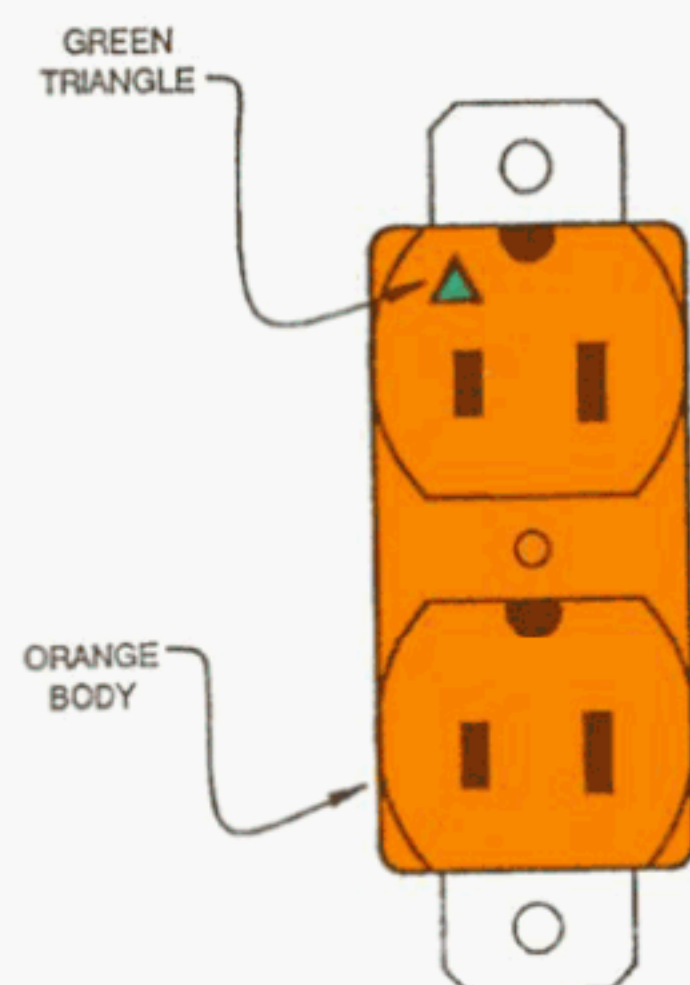
Figure 3 – Typical Field Service situation using Equipotential Bonding

5.3 Other Considerations

5.3.1 Metal bench tops such as stainless steel worksurfaces used in some operations must be connected directly to AC equipment ground with no added resistance. In the event of an electrical short to the conductive surface, safety devices such as fuses or circuit breakers in the electrical system are designed to open and thereby cutoff current flow through that specific path to ground.

Note: Caution should be exercised using metal bench tops if Charge Device Model (CDM) issues exist in the process.

5.3.2 Isolated Ground Receptacles
Isolated ground receptacles should not be used to derive an ESD ground. The use of an isolated ground for ESD purposes may compromise the function of the isolated ground system. See Figure 4.



NOTES

- 1 Not to be used to derive an ESD ground
- 2 Receptacle body and triangle colors may vary

Figure 4 – Isolated Ground Receptacle

5.3.3 ESD Technical Element Conductors

The grounding conductors (wires) from wrist straps, worksurfaces, flooring or floor mats, tools, fixtures, storage units, carts, chairs, garments and other ESD technical elements may or may not contain added resistance. Where added resistance is not present, a direct connection from the ESD technical element to the common point ground or common connection point is acceptable and recommended.

Note: Manufacturers may add resistance to the grounding conductors for purposes other than ESD (e.g. current limiting). Added resistance is acceptable for the purposes of controlling ESD provided electrostatic accumulation does not exceed specific EPA requirements. The typical added resistance in grounding conductors is 1 megohm, although other values may be specified.

5.3.4 Vehicles

The electrical system of vehicles such as ships, aircraft, space craft and surface vehicles have a self-contained electrical system that utilize a neutral bus with equipment grounding conductors that serve as an electrically zero reference point. A vehicular grounding system is acceptable for establishing an EPA within the vehicle and is within the scope of this standard.

5.3.5 Mechanical Requirements

Wires used as the conductor for electrical bonding between ESD technical elements and the common point ground or a common connection point, and from the common point ground to the ESD grounding/bonding reference point, shall be of sufficient strength not to be inadvertently broken or disconnected. The wire shall be electrically insulated and, whenever possible, mechanically supported to physical structures to limit mechanical damage.

6.0 ELECTRICAL REQUIREMENTS

6.1 Instrumentation

6.1.1 DC Ohmmeter

The meter shall be capable of measuring a DC resistance of 0.1 ohm through 1 megohm (or other added resistance value) with an accuracy of $\pm 10\%$ of the value being measured.

6.1.2 AC Circuit Tester (Impedance Meter)

The meter shall be capable of measuring the impedance of the equipment grounding conductor from a receptacle (power outlet used for establishing the AC equipment ground) to the neutral bond at the main service equipment panel. The meter shall also verify wiring orientation.

6.2 Verification Frequency

The grounding system must be verified periodically at the frequency established in a user defined ESD Control Program Plan.

6.2 ESD Grounding System Verification

6.3.1 Equipment Grounding Conductor

The impedance of the equipment grounding conductor from a receptacle (power outlet used for establishing the AC equipment ground) to the neutral bond at the main service equipment panel shall not be greater than 1 ohm. The hot, neutral, and equipment grounding conductor shall be verified to be in the proper wiring orientation in accordance with the National Electric Code (ANSI/NFPA-70). See Figures 5 and 6.

6.3.2 AC Equipment Ground and Auxiliary Ground Verification

If both grounding systems are present, the resistance between the AC and the auxiliary ground shall be < 25 ohms. See Figure 2.

6.4 Technical Elements

ESD technical elements directly connected to the ESD grounding/bonding reference point shall be measured from the groundable point of the ESD technical element to the ESD grounding/bonding reference point.

6.4.1 The resistance of the conductor from the groundable point ground of any ESD technical element (e.g. worksurface, floor, chair, wrist strap, etc.) to the common point ground or common connection point shall not be greater than 1 ohm. Where a resistor is used in the grounding conductor, the total resistance shall include the value of the resistor. See Figure 7.

6.4.2 The resistance of the conductor from the common point ground to the AC equipment ground shall not be greater than 1 ohm. See Figure 8.

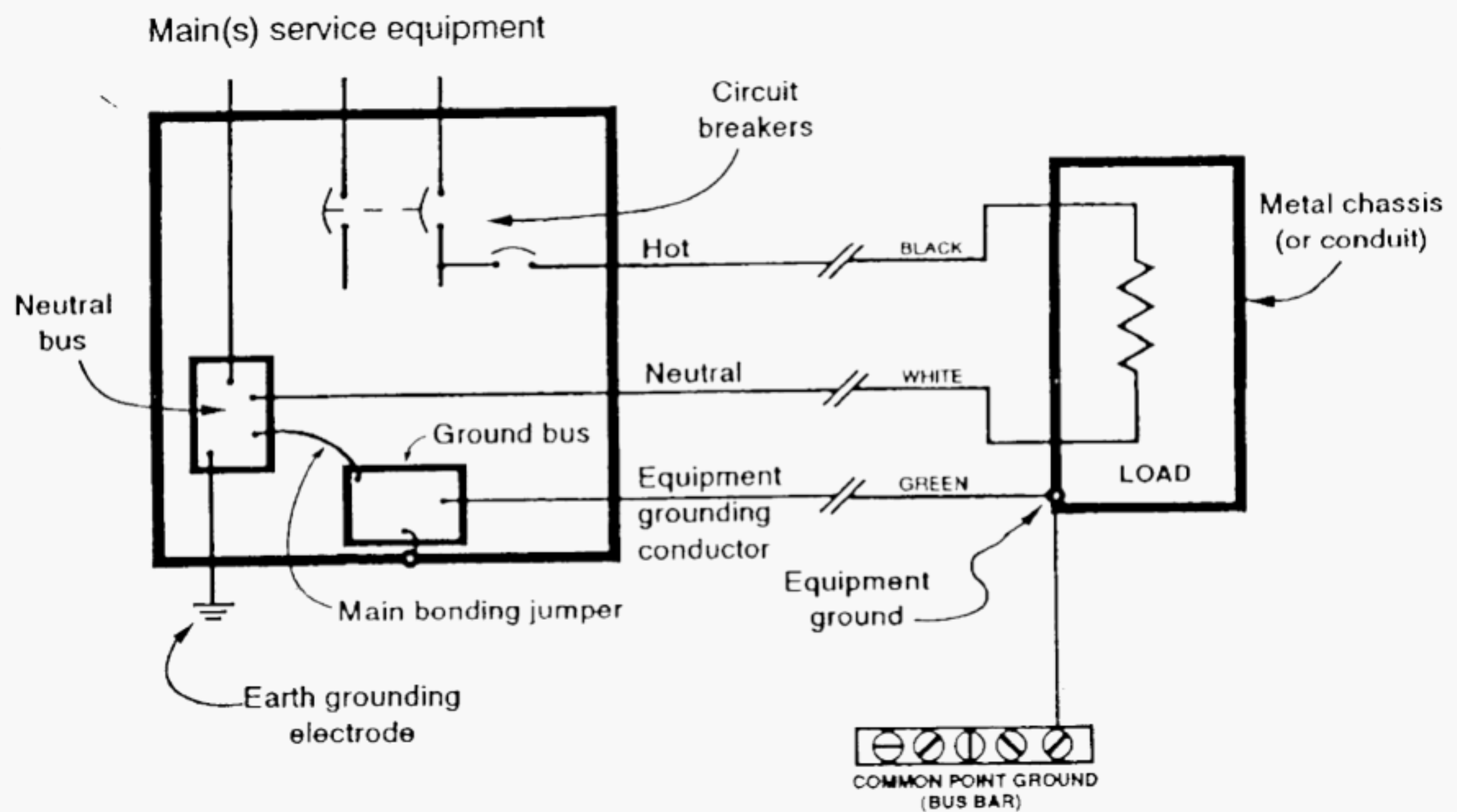


Figure 5 – Main Service Equipment, Single Phase

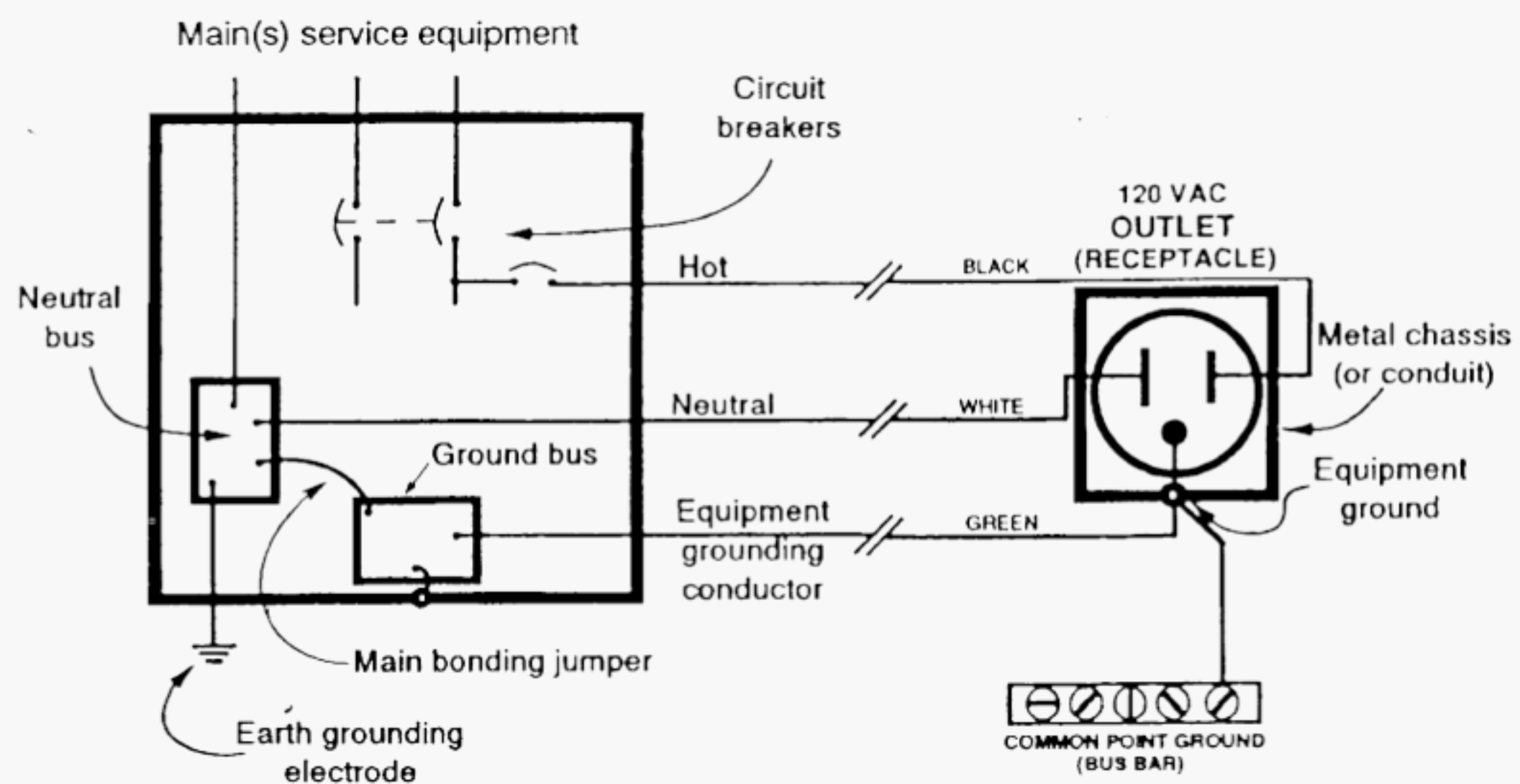


Figure 6 – Typical ESD Ground Connection and Main Service Equipment

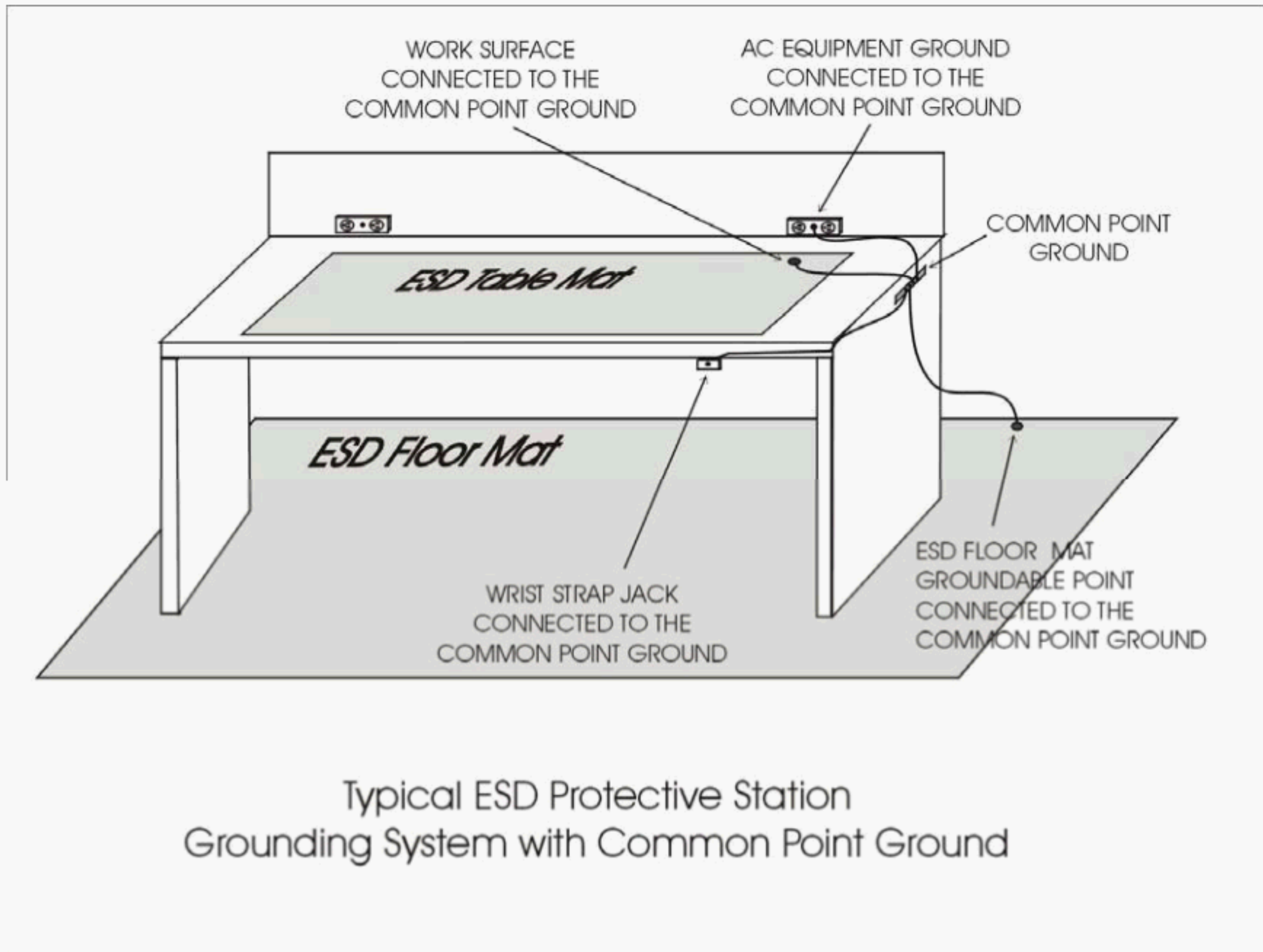


Figure 7 – Typical ESD Protective Workstation with Common Point Ground

6.4.3 Bonding Conductors

Conductors used for electrical bonding between conductive items in a field service application that do not include a resistor shall have a resistance not greater than 1 ohm. Where a resistor is used in the bonding conductor, such as in a standard wrist strap ground cord, the total resistance value shall include the value of the resistor (e.g. a wrist strap ground cord may be

considered a bonding cord in field service applications).

Note: Manufacturers of wrist straps and other bonding conductors may add resistance, typically 1 megohm, to ensure limiting of current flow through that path to ground. This is of particular importance where the bonding conductor is used to connect a person to ground.

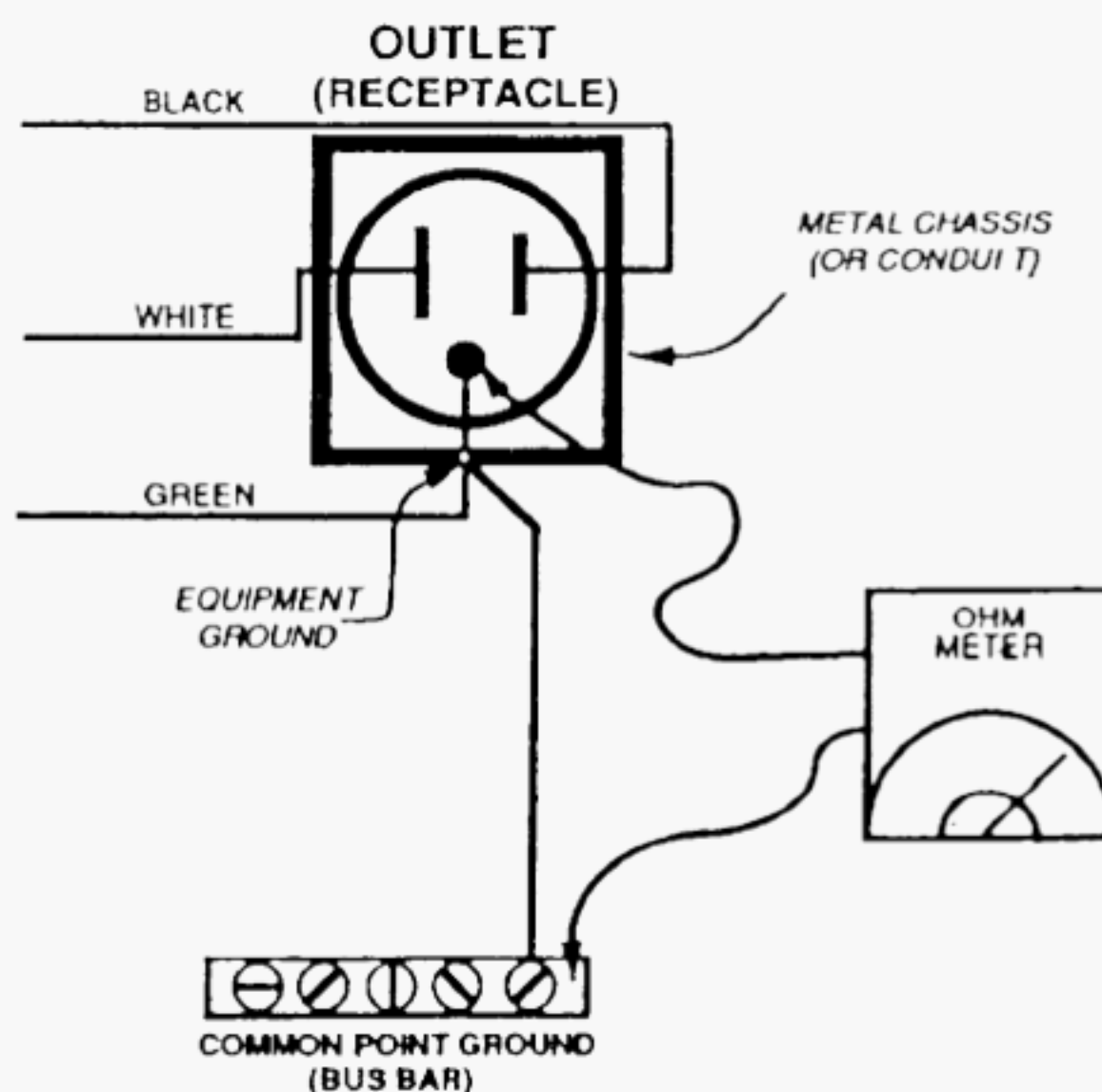


Figure 8 - Example of a common point ground resistance measurement

6.5 Level 2 Technical Elements

The resistance from a Level 2 technical element to the ESD grounding/bonding reference point shall not exceed the resistance level established in a user defined ESD Control Program Plan. Level 2 items include those that rely on contact to a primary ESD technical element to function. As an example, a cart used to transport items within an EPA may make electrical contact through an ESD floor or a floor mat that is attached to ground. The resistance to ground measurement must include the cart and floor in this example. Figure 1A shows the concept involved.

7.0 TEST PROCEDURES

7.1 Receptacle Wiring Verification

These tests check for proper wiring within the receptacle containing the equipment grounding conductor used for ESD ground. Grounding procedures must remain consistent with the National Electric Code (ANSI/NFPA 70) and other applicable codes. Qualified personnel must repair any AC receptacle (outlet) that fails the following

tests before further testing or any use of the AC outlet.

7.1.1 Connect the AC circuit tester (impedance meter) to the AC outlet or receptacle containing the equipment grounding conductor that will be used for ESD grounding/bonding reference point. Verify the following wiring conditions:

- a) Neutral and equipment grounding conductor wires are present and not connected to each other at the receptacle (outlet);
- b) Hot and neutral wires are not reversed;
- c) Hot and equipment grounding conductors are not reversed;
- d) Impedance of the equipment grounding conductor is not greater than 1 ohm.

7.2 ESD Grounding/Bonding Reference Point Tests

7.2.1 Facilities with AC Equipment Ground

The following tests are intended to check the integrity and adequacy of the ESD grounding/bonding reference point. Using an ohmmeter as specified in 6.1.1, perform the following measurements:

7.2.1.1 Connect the ohmmeter between the common point ground and the previously tested AC equipment ground. The measurement probes shall be placed to include the resistance of all the interconnecting and securing devices. The total resistance shall not be greater than 1 ohm. See Figure 8.

7.2.1.2 Connect the ohmmeter between the common point ground and the groundable point of ESD technical elements. The measurement probes shall be placed to include the resistance of all the interconnecting and securing devices. The resistance shall not be greater than 1 ohm. If a resistor is used in the grounding conductor from the ESD technical element, the total resistance value shall include the value of the resistor. See Figure 7 for guidance.

7.2.2 Facilities with AC Equipment Ground and Auxiliary Ground

When both AC equipment ground and an auxiliary ground are present and electrically bonded together within a facility, the following measurement shall be conducted. Connect the ohmmeter between the AC equipment ground and any auxiliary ground. The measurement probes shall be placed to include the resistance of all the interconnecting and securing devices. The resistance shall not be greater than 25 ohms. See Figure 2 for guidance.

7.2.3 Field Service/Equipotential Bonding (Applications without AC Equipment Ground)

In field service applications that do not use the AC equipment ground, connect the ohmmeter between the common connection point and the neutral bus or ground terminal of the item being serviced. The total resistance shall not be greater than 1 ohm.

7.2.3.1 Connect the ohmmeter between the common connection point on the item being serviced and the groundable point of ESD technical elements. The measurement probes shall be placed to include the resistance of all the interconnecting and securing devices. The resistance shall not be greater than 1 ohm. If a resistor is used in the grounding conductor from the ESD technical element, the total resistance value shall include the value of the resistor.