Static Electricity

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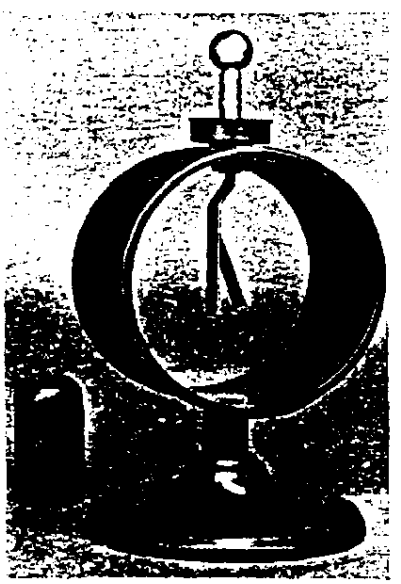
1. Sparks resulting from accumulations of static electricity are a common cause of ignition in accidental fires. Based upon investigation and experience, practical methods have been developed for the prevention or safe discharge of accumulations of static electricity.

2. Static electricity should not be confused with stray currents, although many of the things that can be done to eliminate static will also assist materially in reducing stray currents. Static is a type of electrical charge resulting from the contact and separation of two substances, one or both of which are non-conducting, and from electrostatic induction by a charged object. Its principal hazard is that of fire or explosion due to discharges of sparks in the presence of flammable or explosive substances.

3. Static can be dangerous should a spark be discharged to or from a human body in that it may so startle a person that he may fall or come in contact with dangerous equipment. Relatively high potentials (300 volts and over) may produce discharges which will ignite combustible material or cause muscular reactions in persons.

4. Hazards from static sparks are more severe in dry, cold weather than during humid, warm weather. During winter months, indoor surfaces in artificially heated buildings become dry because of low relative humidity. Consequently, many surfaces decrease in their conductivity and may permit static electricity to accumulate. During summer months when relative humidity is high, most surfaces are coated with a film of moisture which makes them comparatively good conductors, and usually permits the static to dissipate as it is generated.

5. Experiments have proved that static is generated by bringing together and separating two substances, one or both of which are non-conductive. If a sheet of glass is coated with varnish and the varnish is allowed to dry, a static charge will be generated by peeling the dry varnish from the glass. The same is true in cleaning sheets of dried coating material from spray booths. Static is generated in this manner on belts and pulleys at the point the belt comes off the pulley. Experiments indicate that a tight pulley or one under load will generate as much static as a loose belt that slips on the pulley.

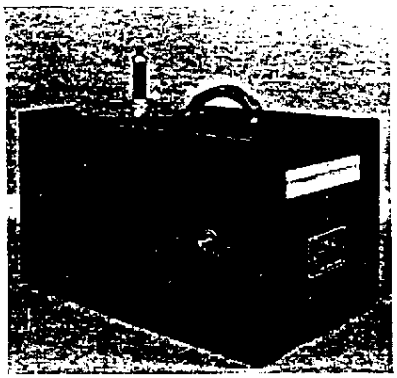


Courtesy Underwriters' Laboratories, Inc.
Figure 1. Gold-leaf electroscope. (See paragraph 11.)

6. The generation of static electricity is difficult to prevent, but few hazards are involved in its generation. The hazard results when static accumulates to such an extent that a spark is discharged. The hazard can be controlled only by preventing static accumulation.

7. Static charges of low potential (low voltage) are very common and fortunately are not always dangerous. They do not cause more trouble because their quantity and voltage are not always sufficient to cause hot sparks, and because an explosive mixture of combustible substances is not always present. The real danger from a static spark is largely a question of quantity, time (involving temperature of spark), and presence of something flammable which the spark can ignite.

8. Tests made by the Underwriters' Laboratories, Inc., reported in Research Bulletin No. 8, "Generation of Static Electricity in Blower Systems," indicate that, "The static charge increases with increase in the concentration of dust or lint, decrease in particle size, velocity of air stream, and with decrease in the humidity of the atmosphere." This bulletin also states, "Not many data are available as to the minimum static charge required to cause ignition by spark discharges. Much depends upon the potential of the system and many other factors. Spark discharges from a circuit of very low electrical capacity charged by a small Wimshurst machine to a potential of 5,000 volts are capable of readily igniting gasoline vapor-air mixtures. It is likely, therefore, that in a blower system static charges of a still lower potential under favorable conditions may cause ignition of readily combustible substances."



Courtesy Underwriters' Laboratories, Inc.
Figure 2. Electrostatic voltmeter. (See paragraph 14.)

9. Voltages which result from moving rubber-tired vehicles, and from rapidly moving belts, conveyors, fabrics, paper and similar material, reach very high values under favorable conditions. Static charges are also produced when liquids, such as petroleum and petroleum products, are pumped through pipe lines and hose. Also, high voltages may accumulate at nozzles or other openings of pipe lines and hose from rapidly issuing steam. However, many authorities believe that pure gas or air forced through pipes and orifices is not electrified and that for charges to be developed, liquid or solid particles must be present.

Detecting Static Charges

10. One simple way to determine the presence of static electricity is to hold a piece of cotton thread near the object to be tested. If static is present, the fibres of the thread will stand out, giving the thread a bristle-like appearance.

11. Another way to detect a static charge is through the use of a gold-leaf electroscope. The instrument is practical for industrial use but is comparatively delicate and will not withstand rough handling. Some persons object to its use because it is too sensitive to small charges and because it will indicate the presence of a static charge but will give no indication of the strength of the charge except in an approximate degree. (See Figure 1.)

12. Another instrument that can be used to detect static charges is the neon tube tester. This device is frequently used for testing spark plugs. It consists of a small cylindrical case containing a condenser at one end, a metallic top at the other, and between them a Geissler tube made of glass containing neon gas. When the tip is touched to a body containing a static charge, or even brought near it, part of the charge passes through the tube into the condenser, causing a bright, reddish-orange glow in the tube. These tests, however, are not always satisfactory.

13. It should be borne in mind that in detecting static the neon tube will ordinarily glow only until the condenser in the handle becomes fully charged. Once the condenser has been charged, no more static will flow through the tube to produce a glow. It is therefore necessary to discharge the condenser by grounding the tip, after which it can be used again. The neon tube tester should never be used if there is a possibility that contact may be made with an electric power or lighting circuit, inasmuch as there is danger of shock.

14. A fourth method of detecting a static charge is to use a static voltmeter. This instrument indicates not only whether an object is charged, but also the voltage of the charge. (See Figure 2.)

Rubber-Tired Vehicles

15. Static electricity may be generated on rubber-tired vehicles by the rolling contact of the tires with roadway surfaces. Such charges on passenger vehicles are not only a nuisance, but may be hazardous. In the case of tank trucks carrying flammable liquids, such charges may be hazardous.

16. Static charges on vehicles have become such an annoyance to bridge toll collectors that grounded wires have been set in the pavement on the approach to the toll collector's stand. These wires make contact with the under-carriage of cars and discharge the accumulated static to ground.

17. The operation of motor buses over city pavements may cause such vehicles to become highly charged with static. This is borne out by the experience of a motor bus company in one of the larger cities. Numerous complaints were made by patrons that in stepping off or onto a bus platform on certain days, slight shocks would be felt when they touched the hand-holds. The company grounded all of its buses by steel wire cables fastened to the brake and clutch levers which are electrically bonded to the chassis. When the brake is applied, the wire cable is thrown into contact with the ground, and if ground conditions are favorable, any static that may have collected on the motor bus is discharged. Since the buses have been grounded, there have been no further complaints.

18. In addition to the use of steel cables for grounding on motor vehicles, strips of conductive rubber and tires made of conductive rubber have been used successfully for grounding static electricity. Of course, the road surface must be conductive if this means of grounding is to be effective.

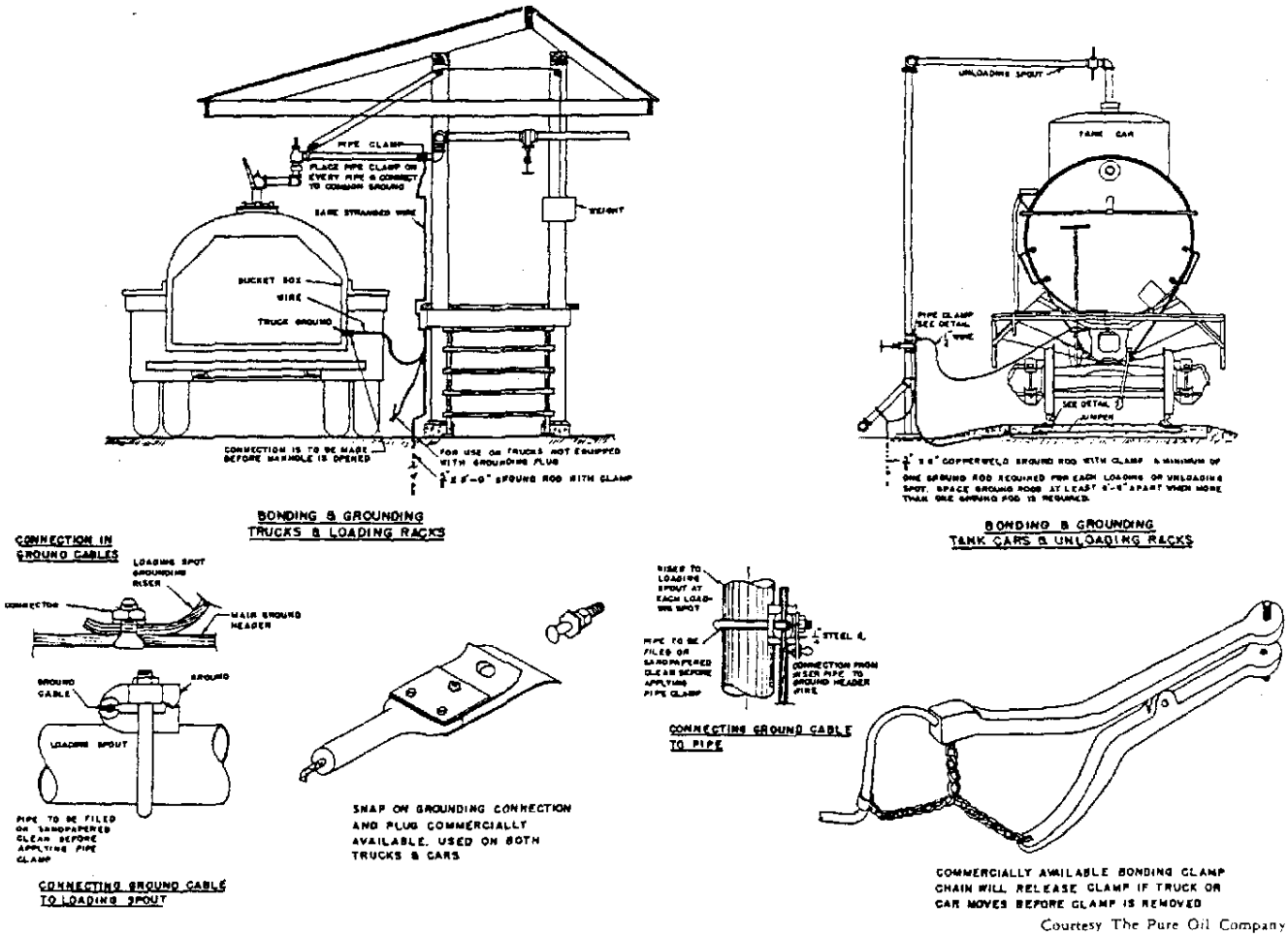
Tank trucks

19. A number of fires and explosions have been attributed to static discharge on tank trucks hauling flammable liquids. However, it is believed that in some cases the true sources of ignition were not determined and for lack of explanation were attributed to static.

20. There are two sources of static electricity to be considered in the transportation of flammable liquids in tank trucks. One is the movement of liquids through hose and pipe lines and the drop through space into containers during filling operations. The major source of static generation is the rolling contact of rubber tires on road surfaces. The latter is particularly dangerous when the charge persists through the early part of the loading or unloading operation.

21. To prevent the accumulation of static charges and the dangers due to spark discharges during loading and unloading operations, it is essential that storage tanks, tank trucks, and connecting pipe lines and hose lines be electrically interconnected before any of the gauge or fill openings are opened. It is important that the truck tanks, chassis, springs and axles be electrically bonded, if construction does not of itself provide electrical connection; also, that the chassis of trailer and semi-trailer units be electrically connected with the tractor chassis.

22. When loading, it is essential that



Courtesy The Pure Oil Company

Figure 3. Grounding of tank cars and trucks.

tank trucks be electrically interconnected with the loading lines. (See Figure 3.) When unloading, it is essential that the tank truck be electrically bonded to the unloading connection, or to the container to be filled. Particularly is this true when pumping off furnace oil, gasoline, etc. Such connections should be made before any of the gauge or fill openings are opened.

23. The unloading hose can be made to serve as the bonding connection by building a static wire in the hose and bonding the ends to the hose coupling. It is preferable to make use of tight connections between the unloading hose and the tank. When a funnel is used, it should be provided with a good metal-to-metal contact with the filling pipe and tank.

24. *Example:* At its loading platforms one large oil company has constructed an overhead ground connection which hangs out over the trucks when loading, and which is connected to a metal contact lug welded on each truck. Workmen are required to attach the ground connection to the truck, thus equalizing the potential between the fill pipe and the truck. An overhead sign cautions workers to "Ground Your Truck Before Loading." (Note: Grounding connections should be hung well clear of the tank; otherwise they provide a discharge point for static as the truck drives under the loading lines.)

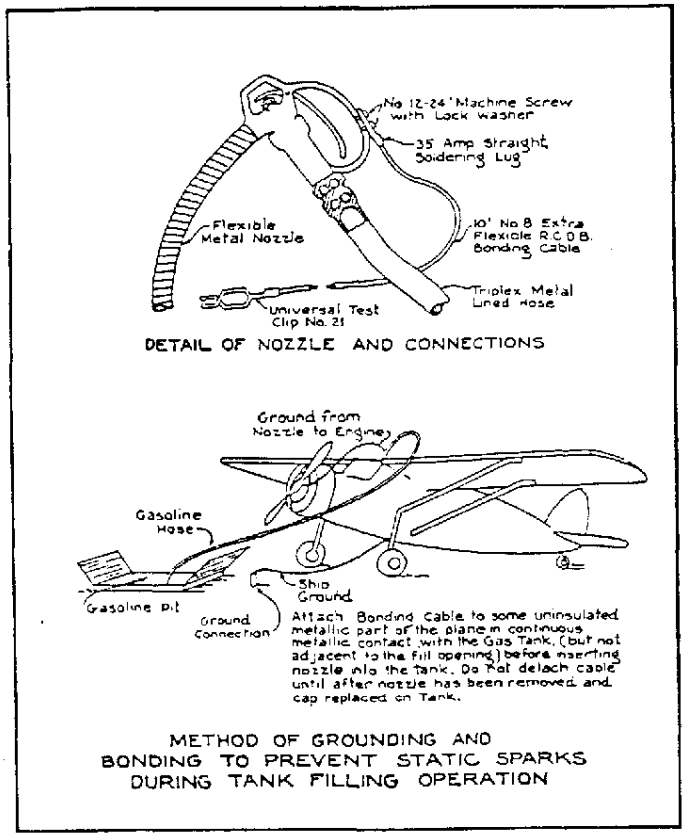
25. *Example:* Another company, to ensure a continuous electrical connection between the tank truck and storage tanks, devised an interlock for the loading cap of the truck. The loading cap is normally locked in a closed position. Before the truck can be filled, it is necessary that the cap be unlocked by the grounding plug attached to one end of the storage tank grounding line.

26. The use of drag chains on tank trucks has been eliminated in the latest specifications of both the American Petroleum Institute and the National Fire Protection Association. This elimination resulted from conclusive proof by various agencies that a drag chain serves little purpose and, even under ideal road conditions, drains off only slightly more static charge than is drained from transports without chains.

27. It is felt that the drag chain on tank trucks might be relied on to drain off charges during loading or unloading operations and thus give a false sense of security.

28. Some states and municipalities require that drag chains be used, and such laws must be complied with.

29. Tank cars should be protected in filling and unloading by permanent bond between the track and the filling or unloading line and by a temporary



Courtesy National Fire Protection Association

Figure 4. Method of grounding and bonding to prevent static sparks during tank filling operations. (See paragraph 32.)

bond between the filling stem and the car. The car tracks and the pipe lines should also be connected to ground. (See Figure 3.)

30. Ground connections of low resistance should be installed. Many industrial concerns now require less than one ohm resistance for a ground to prevent static accumulations. The main object is to provide a path just as short and easy as possible, from the point of generation of static to ground.

31. The Association of American Railroads (Circular No. 17-C) requirement for loading or unloading tracks is as follows:

A permanent electrical connection shall be made between the rails on which rail equipment may stand and the piping system used in connection with the transfer of inflammable liquids. The electric connections shall not be less than one No. 4 or less than two No. 6AWG stranded copper, bronze or copper-covered steel wire.

Airplane Fueling Operations

32. The National Fire Protection Association (National Fire Codes for Flammable Liquids and Gases) recommends the following precaution in airplane fueling operations (see Figure 4):

(a) Gasoline hose shall be triplex metal lined or equivalent, with an adequate bonding cable securely attached to the nozzle.

(b) Before gasoline is transferred to airplane tank, the clip on the bonding cable shall be attached to some uninsulated metal part of the airplane in continuous metallic contact with the tank but not adjacent to the tank filling opening. The bonding is absolutely necessary to equalize static electrical charges and to prevent static sparks.

33. (See Data Sheet D-A. 1, "Electrical Grounding of Airplanes.")

Other Flammable Liquid Containers

Tank vessels

34. Steel vessels are inherently grounded to the sea, but independent tanks in wooden vessels require separate grounding. General rules and regulations prescribed by the Board of Supervising Inspectors, Bureau of Marine Inspection and Navigation, recommend:

All independent cargo tanks in wood hull tank vessels shall be electrically bonded together with stranded copper cable of not less than No. 4 B and S gage, and one end of this cable shall be grounded to a copper or brass plate of not less than two square feet in area and $\frac{1}{4}$ inch in thickness, and this plate shall be securely fastened to the hull, on the outside, at a point where it shall be covered by water when the tank vessel is unloaded.

35. The grounding of shore pipe lines and electric bonding between pipe lines and the ship are important, and an established procedure should be followed in making the bond. The National Fire Protection Association Regulations governing marine fire hazards require that:

Before attaching hose for loading or discharging, an electric bond shall be established between the ship and shore by means of a No. 4 B and S gage copper cable. The cable shall be connected to the ship with switch or plug open, bond closed after attachment, and left closed until all cargo movements have been completed and hose disconnected. The bond shall be broken by pulling the switch or plug and then disconnecting from the ship.

Portable gasoline containers

36. In filling a pail from a tank truck, sparks may occur if the container does not make a metal-to-metal contact with the truck. Wooden or painted handles on the bails of cans serve to insulate them from the truck and permit a difference in potential to build up. Only cans with bare metal bails should be used.

37. In transferring flammable liquids from one metal container to another, the containers should be in contact with each other or electrically interconnected throughout the transfer so as to prevent accumulation of static charges. Where portable tanks, mixers or processing vessels are used for flammable liquids or compounds, they should be electrically bonded and grounded at places where they are filled or emptied. (See Figure 5.)

38. If safety cans are filled with flammable liquids from drums or barrels, the can and drum should be electrically connected to each other and to ground. If gasoline filling station dispensing hose is used, a connection between the drum and can is made by a metal-to-metal contact between the hose nozzle and the can. (See Figure 6.)

Barrel or drum filling

39. In filling barrels with flammable

liquids, provision should be made to establish metal-to-metal contact between the filling stem and the drum, or preferably an electrical bond should be installed between the barrel and the filling stem. This can be done by placing a metal plate under the drum at the filling point and bonding the plate to the filling spout or stem. Another method is to use a cable with one end fastened permanently to the filling stem and the other end attached to the drum by means of a spring clamp.

Tank steaming, cleaning

40. Tank steaming and cleaning can be very dangerous operations due to the static accumulations if all steam lines are not connected and bonded to the tank. But if the bonding is intelligently done, a difference in potential cannot be built up. All nozzles or pipes through which steam and water are discharged into tanks should be effectively bonded to the grounded tank.

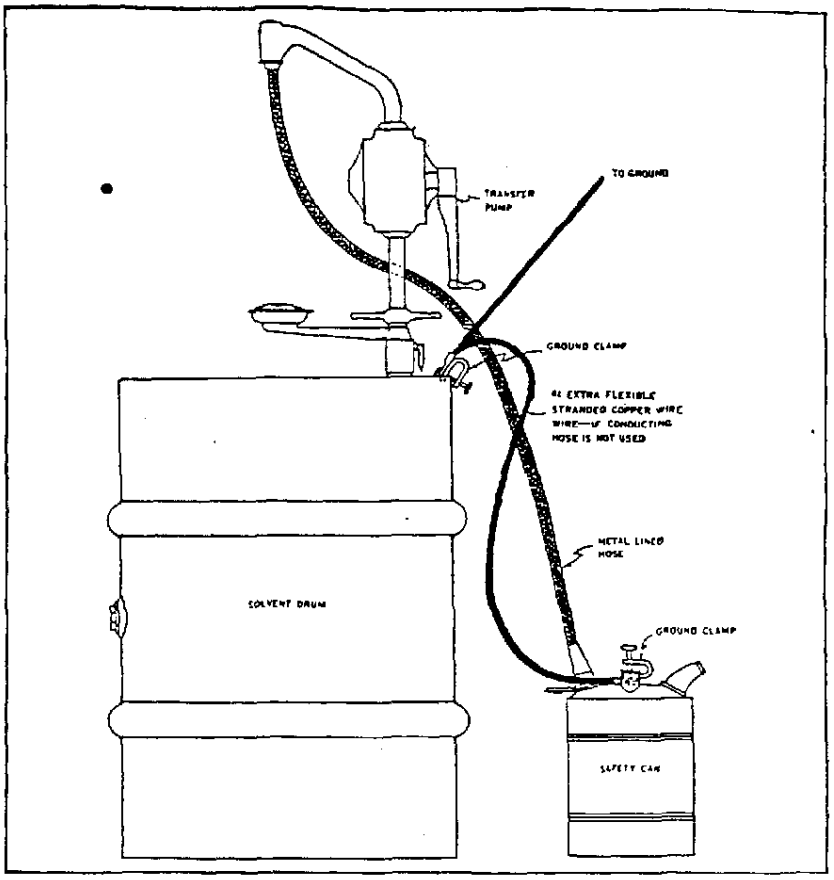
Metallic structures

41. Oil companies have found it advisable to bond all parts of the permanent distribution and storage equipment. (See Figure 7.) One oil company makes a practice of bonding together not only all its metallic or metal-covered buildings, tanks, pipe lines, etc., but also all parallel or nearby railroad tracks, both main lines and spurs.

42. Numerous fires at first attributed to static have been traced to other causes. Stray currents leaking from electric railway tracks to steam railway tracks and sidings from them, set up a difference of potential between tank cars standing on the side tracks and the oil piping system provided for unloading the tank cars. This situation is aggravated where the steam railway tracks make a direct crossing with electric railway tracks. Insulating of side tracks and bonding of pipe lines to side tracks and all other equipment will help remedy this condition.

Belts

43. Static electricity is generated on drive belts by the contact and separation of the belt and pulley. As well as on drive belts, static charges are also found on conveyor and other types of belts. In one case, a charge of 45,000 volts was reported on a rubber belt conveyor carrying grain.



Courtesy National Fire Protection Association

Figure 5. Grounding of portable flammable liquid containers. (See paragraph 37.)

44. In addition to the fire and explosion hazard, a heavy static charge on a belt may cause direct physical injury by attracting the hair of a person walking under or near it. Serious injuries have occurred where a girl's hair was attracted by static into contact with a belt and pulley.

Grounding belts

45. The static charge on a belt is not always eliminated by grounding the pulley or shaft; the belt itself should be effectively grounded. Investigators of the U. S. Department of Agriculture recommend the use of two wire combs, grounded and placed in contact with the belt at the points where the belt leaves the pulley. Satisfactory results have also been reported from placing metallic combs close to, but not touching, the surface of the belt where it runs off the pulley. The points of the comb should be needle sharp. (See Figure 8.)

46. A comb can be made by clamping No. 80 mesh bronze wire between brass or bronze strips and placing it so that the wire ends are not more than 1/8 inch from the belt. The comb is then connected to ground. In some cases, metallic tinsel wrapped on a wood base has been effective in collecting static charges.

47. In grounding belts in a dry-cleaning establishment or other places where explosive vapor may be present, the comb, if used, must be either in contact with the belt or very close to it, so there will be only a brush discharge. If placed too far away, there will be "hot" sparks between belt and comb which may ignite the vapor. Combs are not commonly used in the presence of ether and other highly explosive vapors. This hazard can be greatly reduced by using metal pulleys and belts made of conductive rubber or their equivalent.

48. Conductive rubber belting has proved satisfactory in the control of static charges. In many cases, such belting is preferable to combs and other

devices. Static combs and brushes become misplaced and damaged due to the breaking of belts. If they are not repaired and adjusted promptly and well maintained, they may cause flash fires in explosive atmospheres.

49. *Various types of belt dressings* have also been used successfully in controlling the static hazard. One company reports success from periodically applying to the outer surface of belts an emulsion of one-half glycerin and one-half water. The glycerin attracts and holds the moisture. The effect of this is to form a film of moisture on the belt which conducts the static charge through the pulleys which are grounded. This substance should be applied with a brush when the belt is not in motion.

50. Many companies have used effectively colloidal graphite and carbon tetrachloride as a belt dressing in controlling static discharges. Another company uses castor oil, well worked into both sides of the belt, followed by a coating of graphite grease applied to the outside. Another secures satisfactory results on a 6-inch belt by cleaning the inside of the belt and applying ordinary belt dressing. In these cases, the dressings act as a conductor of static.

51. One investigator has reported recently testing the following formula for an anti-static leather belt dressing, and found it satisfactory. The quantities given below suffice for about one quart of dressing:

Fish glue	9 ounces
Glycerin	7 ounces
Sulphonated castor oil	7 ounces
Water	12 ounces
Lampblack	6 ounces
Ammonia water (2% solution)	2 ounces

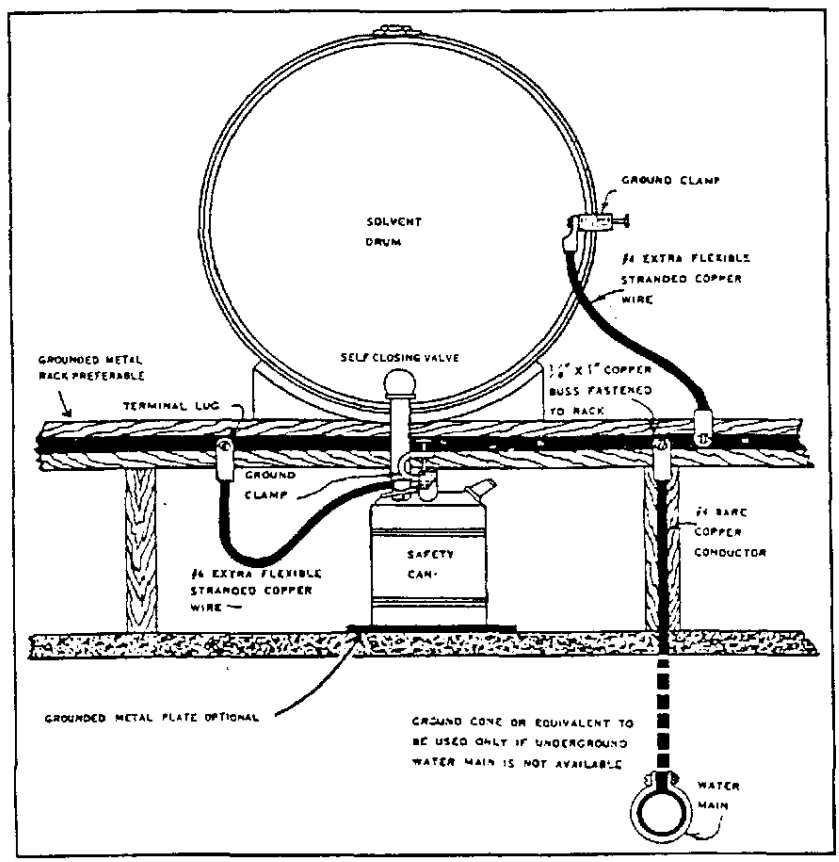
The ingredients of this formula are added individually, in the order given. The glue and glycerin are first heated together for two hours with frequent stirring at a temperature at which the mixture barely boils; and the other ingredients are stirred into the mixture. The requisite quantity of 2% ammonia water can be made by adding ¼ ounce of ordinary household ammonia to 1¾ ounces of water. This mixture should be applied while the belt is not in motion, and should be allowed to dry before the belt is placed in operation. The dressing should be applied to the pulley side of the belt. A weekly application is usually sufficient to keep the static down to a negligible amount.

52. A formula with similar ingredients is recommended by the National Fire Protection Association in their bulletin, "Belt Dressing for Eliminating Static." It is as follows:

Fish glue	100 c.c.
Glycerine	80 c.c.
Sulphonated castor oil	100 c.c.
Water	170 c.c.
Lampblack	82 grams
Ammonia water (2% solution)	20 c.c.

This dressing is easily applied with a brush but should not be applied while the belt is moving. It is not necessary for the dressing to dry before the belt is run. However, if the belt has not been properly maintained, this dressing will cause the belt to stretch slightly.

53. It has been reported that a mixture of nine ounces of high grade spar varnish and one ounce of lampblack makes a good dressing for rubber and composition belts. If a thinner is required to facilitate the application of the dressing, one which is relatively non-hazardous may be made by mixing together equal parts of varnish maker's naphtha (70° to 72° Baume) and carbon tetrachloride. In most cases, only a small amount of thinner will be needed. This mixture should be applied while the belt is not in motion and should be allowed to dry before the belt is placed in operation. The dressing should be applied to the pulley side of the belt.

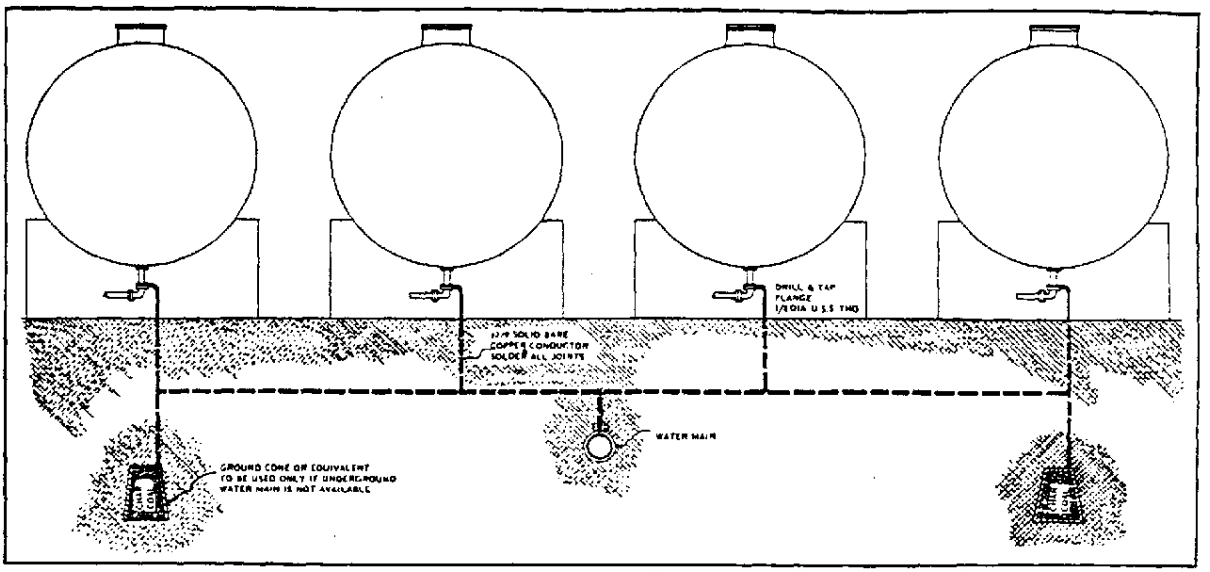


Courtesy National Fire Protection Association

Figure 6. Grounding of solvent containers. Outdoor installation. (See paragraph 38.)

Grounding shafting

54. It is also important that the shafting of all metal pulleys be effectively grounded. Copper brushes used on electroplating dynamos are suitable for this purpose. Such brushes depreciate very little over a long period of time and require a minimum of attention. Shafting is usually grounded by grounding the bearing. If there is any doubt about an effective ground due to the lubricant used in the bearing, then the shaft and bearing should be grounded separately. (See Figure 9.)



Courtesy National Fire Protection Association

Figure 7. Grounding of solvent storage tanks. (See paragraph 41.)

55. There are many cases where the grounding of shafting is useless, even in connection with high speed belts, as in cases where wood, paper, or wood base pulleys are used. In such cases, the charge should be collected as fast as it is formed from the face of the pulley with a comb or its equivalent, mounted on the open side of the pulley. Also, it is well to bear in mind that in many cases the static problem can be eliminated entirely by substituting chain or gear drives.

56. The methods of collecting static accumulations from belts and shaftings and other equipment are not effective unless the connection is properly made. In buildings, it is usually sufficient to make a ground connection to the cold water piping. If grounding connection is made to a water line which includes a meter, an electric "jumper" should be installed around the meter, since some water meters are good insulators. A grounding connection should never be made to a gas or oil pipe line. Static grounds should be made in multiple as a safety precaution.

Dry-Cleaning Establishments

57. The contact and separation of material being dry-cleaned generate static charges which accumulate on the machines and on the fabrics. Unless these charges are dissipated by means of grounding, by humid atmospheres, or some other manner, fires and explosions may result should sparks occur. Because fabrics are usually poor conductors, grounding may not always be sufficient to prevent static from accumulating. Some companies make it a practice of allowing dryers and washers to stand for five minutes or more after the machines have been stopped so that static charges can be drained off.

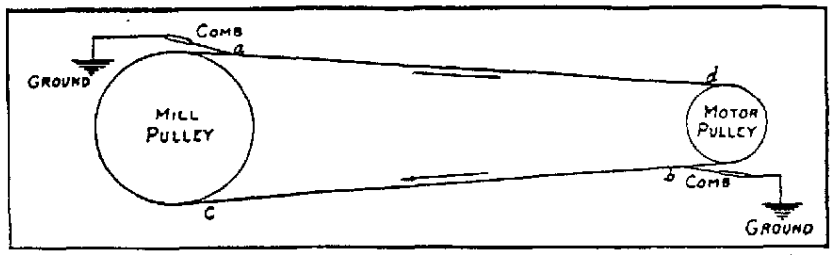
58. All dry-cleaning equipment, including storage tanks, reclaiming tanks, pumps, piping, washers, drying tumblers and extractors, should be effectively bonded and grounded. Underground storage tanks located in dry, sandy soil or covered with corrosive-resisting substances or other insulating materials, should also be equipped with ground connections.

59. Pipe lines containing flanges with gaskets should be bonded across the flange unless a good metal-to-metal bond is secured by means of the flange bolts. Also, all piping, pipe outlets and pipe manifolds should be bonded to ground. Safety cans for transporting solvents should be grounded when they are being filled or emptied.

60. Cylinders of washing machines and tumblers should be grounded through shaft ends and bonded to the machine shells. Some drying tumblers are provided with a device which admits live steam during the first four or five minutes of operation; this keeps the contents damp, thus leading off the static charges, and also helps to extinguish any small fires that may occur.

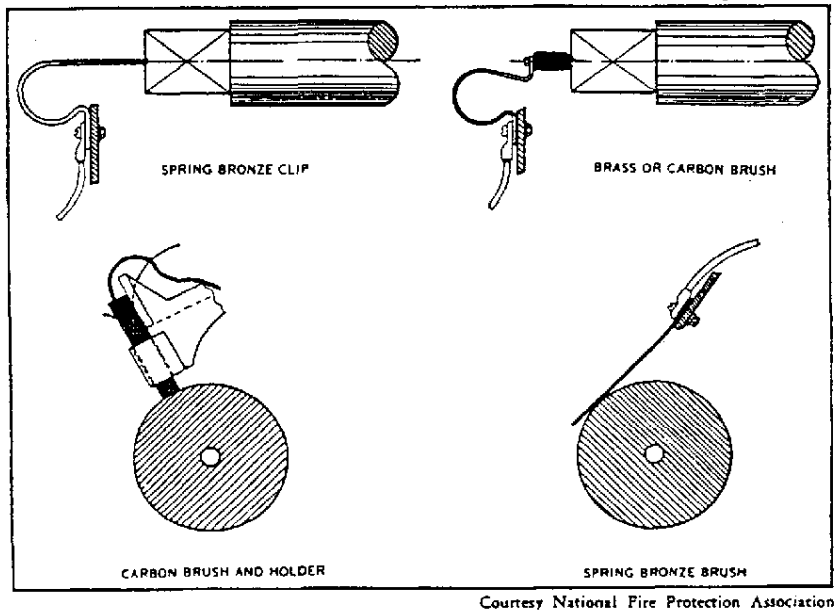
61. Several explosions, fires, and at least two deaths have resulted from ignition of residual vapors in cleaning fur garments. Linings of garments sponged with a mixture of carbon tetrachloride and a flammable solvent are first tumbled in sawdust in drums, and then cleaned in "cages." The tumbling process removes the greatest part of the carbon tetrachloride but leaves the slower-evaporating but more dangerous solvent vapors on the garments. Static electricity generated in this process is sufficient to cause ignition. The accumulation of static can be prevented by grounding the cage barrel and grounding the operator by means of a metal floor plate. Also, thorough airing of garments between processes will lessen the fire hazard.

62. Fire hazards due to static sparks are greatly reduced in modern dry-cleaning plants by use of closed systems in which volatile solvents are kept out of contact with air. Clothing and other materials to be cleaned are placed in a washer with an air-tight door. Air is exhausted from the washer by means of a vacuum pump before the cleaning fluid is introduced. After the cleaning operation is completed, the cleaning fluid is drawn off and the garments dried before the machine is opened. In this process, no flammable mixture can accumulate in the machine. Also, there is no appreciable vapor given off by the goods when removed from the machine. This process not only increases the



Courtesy National Fire Protection Association

Figure 8. Proper location of combs for removing the static from belts. (See paragraph 45.)



Courtesy National Fire Protection Association

Figure 9. Positive methods of grounding shafting or metal rolls. (See paragraph 54.)

safety of a plant, but results in economical operation since the system is entirely enclosed and the solvent vapors are reclaimed.

63. Provisions should be made for humidifying dry-cleaning rooms in cold, dry weather and in dry climates. Since cleaning establishments are comparatively small, they lend themselves readily to such air conditioning. It is advisable to provide automatically-controlled humidifiers that will guarantee a high relative humidity at all times. Although a relative humidity of 60 per cent or higher is desirable, it is difficult to obtain in northern climates in cold weather except in buildings especially constructed for this purpose. If a minimum relative humidity of even 50 per cent is to be maintained, double windows will be required. Otherwise, the moisture in the air will condense on the cold window glass.

64. Another method of lessening the static hazard is to mix a conducting material with the fabrics being cleaned. This result is obtained when silks are lightly steamed before running through a dry-cleaning operation. In this case, the moisture in the fiber of the silk conducts the charges away as fast as they are formed, to some grounded part of the machine.

Static in Powdered Materials

65. Powdered material, if permitted to fall through the air or blown through a pipe, or ejected from small nozzles or orifices, as in spray drying or dust-collecting and conveyor systems, may generate static electricity. Such a charge becomes dangerous if the powdered material forms an explosive dust mixture with the air, thus furnishing fuel for a static spark to ignite. It has been proved that any flammable dust may explode under favorable conditions, and that static sparks may be sufficient to ignite the dust.

66 One company reports that granular or pulverized non-conducting materials, if dry, easily become charged with static electricity when they are moved. The motion of the materials need not be violent; a bag of thoroughly dry material, sensitive to the formation of static, may on a dry day accumulate a charge if merely lifted from the ground and set down again.

67. Dry materials become charged when allowed to slide down a metal or wooden chute. The charge is distributed over the individual particles and cannot be readily discharged. There is a tendency, however, for a spark to occur at the moment the last of the material leaves the chute.

68. Static sparks are said to be produced by emptying a single tray of dry, smokeless powder. Static electricity does not accumulate, however, if the air is damp or the powder is "green."

69. Conductive rubber tubing has been found to be effective in reducing static charges in dust-collecting and conveyor systems. In some cases, inert gas has been used instead of air in conveyor tubes to avoid the accumulation of an explosive mixture.

70. One authority states that static may be found on rust particles escaping through the needle valve of a compressed gas tank. Experiments have shown, it is said, that hydrogen gas escaping from such a tank, rusted on the interior, may thus be ignited.

71. Machinery or equipment in which material is finely divided, or through which powdered or finely divided material passes, should be electrically bonded and grounded at a sufficient number of points to ensure the collection of all charges. This method of grounding such machinery has been found very efficient in preventing the fires which formerly occurred from static sparks igniting cotton in a cotton gin mill.

72. Threshing machinery should be similarly grounded where there is any danger of static. One year when the weather was dry there was a serious epidemic of threshing machines fires caused by static in several western states. The trouble disappeared entirely when the apparatus was grounded.

73. A manufacturer of a food product had trouble with static where the finely ground grain was blown through cloth screens. This was eliminated by the use of fine copper wires woven into the screen and grounded.

74. Serious trouble in connection with collection of sulphur dust, in a filter-type collector, has likewise been eliminated by grounding the collector bags. Another company, however, reports that after repeated experiments it was unable to remove, by grounding of apparatus, the static charges which occurred on wood pulp in the process of drying and sifting.

Rubber Industry

75. The high insulating properties of the solvents and materials handled in the rubber industry are conducive to the formation of static electricity. The separation of fabrics, rubber strips, etc., in process tends to create static charges.

76. Static hazards in the rubber industry may be guarded against by several safety measures, including the use of high humidity, grounding, and static eliminators. Where humidification is used, it should preferably be maintained at least at 50 per cent or 60 per cent of saturation. While grounding the machinery will not always give 100 per cent protection against fires, it will provide some degree of safety. Occasionally, a combination of humidity, grounding and the use of static eliminators is used to control this hazard.

77. Metal parts of buildings including door and window frames, should be well-grounded. Grounding should include piping and all machinery, belts and other moving objects. Metallic platforms which are grounded should be provided in front of all such equipment as spreaders and churns, so located that employees are obliged to stand on the platforms.

78. Material passing through spreaders should be thoroughly grounded by a number of collecting points in contact with the material or by thoroughly grounded metal rollers provided for that purpose. (See Figure 10.)

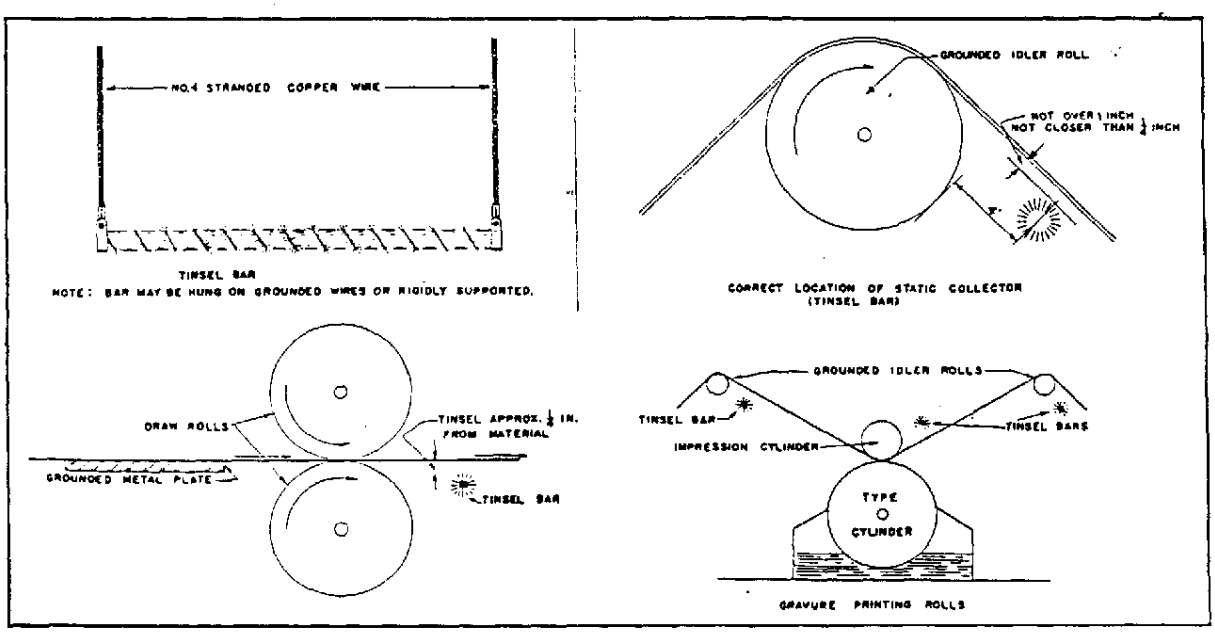
79. One company reports a fire that occurred on a work table about 60 feet long. Material which had been coated with rubber cement and was piled on a zinc-covered table was being separated by employees. This operation charged the zinc top of the table and the charge traveled along the table top to a point close to where the zinc coverings were about ¼ inch apart. The spark ignited the vapors from the stock and started the fire, which opened 12 sprinkler heads. To prevent a recurrence, the zinc table covering has been soldered together, and ground wires securely soldered to the table to carry away any charges that may be generated.

Printing and Textile Plants

80. Electrostatic attractions and repulsions give rise to a great deal of trouble in the handling of such non-conducting materials as paper and textile fibers. Although usually only the carrying on of the required process so as to get a good product is affected, sometimes a hazard results. For example, sheets of paper handled rapidly in a dry atmosphere acquire a charge of static, which makes it difficult to pile or stack them.

81. When a stack of paper sheets is placed upon the table of a guillotine paper cutter, it is necessary to clamp it solidly just back of the point of operation of the knife. If the sheets are charged, there is difficulty in getting them properly clamped, and many injuries have occurred in an effort to smooth out such a pile of paper.

82. A similar hazard is found where paper is hand-fed to some printing presses. If the sheets are so charged that they will not readily slide into place against the stops, there is a temptation to reach in and smooth them into



Courtesy National Fire Protection Association

Figure 10. Grounding for static removal from non-conducting materials. (See paragraph 78.)

place. To do this is of course extremely dangerous and results in many serious hand and finger injuries.

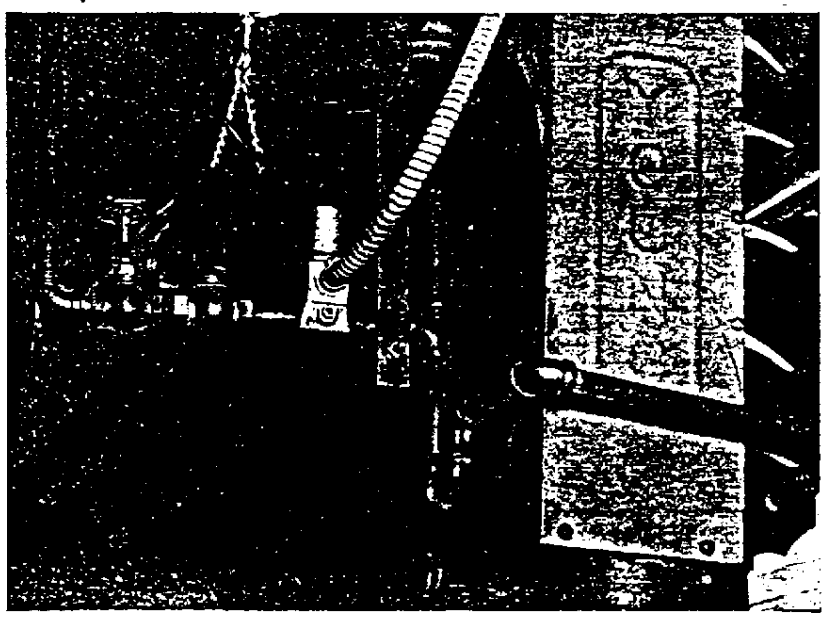
83. The printing press hazard is largely eliminated by getting rid of static charges. The air may be kept very humid, which will render the paper or fabric moist enough to be a conductor, so that the static is discharged to the machine or any other grounded conductor over which the paper passes. Also, various methods of grounding may be employed, including the use of metallic tinsel wrapped on a wooden bar and placed near the point where the static is generated. The tinsel, of course, must be grounded.

84. The static problem is often controlled in paper conversion machines by maintaining a relative humidity of 50 per cent at 72 degrees F. When these conditions of humidity and temperature are maintained constantly, there is sufficient moisture in suspension in the air to dispose of the minute static charges which accumulate in paper material.

85. The relative humidity is obtained by installing a wet steam jet on each blower-type heater. Wet steam for the jet is secured from the return steam line from the heaters and is discharged into the intake side of the blower. The velocity of the air passing through the heater and the blower blades tends to atomize the moisture. The heated coils prevent condensation in the blower. The heated air readily takes up the moisture and the blower distributes it throughout the room. The wet steam jet is controlled by an electrically-operated valve which is operated by a humidistat when the relative humidity drops below 50 per cent, and closes when the relative humidity reaches 55 per cent. (See Figure 11.)

86. Another method of controlling the static in the printing industry is by the use of a gas flame. The flame is also used to aid in drying the ink as the paper comes from the presses. Of course, the use of an open flame in the presence of flammable vapors is extremely dangerous. This hazard is present in various types of printing, especially rotogravure printing. It is preferable to use high humidity in place of the gas flame.

87. Another method is the use of the static neutralizer or static eliminator, a device which has been successful in the paper and textile industries. It consists of a bar over or under which the paper or fabric passes without actually touching it. The bar may be supplemented by a second bar so that the paper or cloth passes between the two. The bar or bars are connected to a source of fairly high alternating voltage, but low amperage. The bar is provided with points extended toward the surface of the material to be discharged, but not touching it. The charged points dissipate the static on the paper or other material by carrying the static off or neutralizing it with a like charge of opposite sign. (See Figure 12.)



Courtesy International Business Machines Corp.
Figure 11. Homemade humidifier. (See paragraph 85.)

88. There has been a good deal of discussion as to the wisdom of employing the above kind of device in places where there is an exposure to flammable or explosive vapors and gases. There is no doubt that this device will dispel a large part of the troublesome static on a fabric, for instance, but the use of the device has not been universally approved. There is a feeling that it is unwise to expose a conductor, such as that of the neutralizing bar, at a voltage capable of producing a spark in such a location.

Steam Jets

89. Static is also said to be generated during the escape and condensation of steam. In one experiment, a horizontal jet of steam was shot into the air. Practically no charge of static electricity was found on the hose, but a wire placed 15 feet from the outlet of the hose collected a charge. This experiment was made after there had been a serious explosion of benzol vapor in an empty tank car being cleaned by steam.

90. One authority refers to a similar experiment in which "Steam, issuing from a boiler, produces a cloud in a high state of electrification, resembling a thunder cloud on a small scale," and says that this "is probably dependent upon modification of surfaces or surface tension." Drops of water must be present in the steam to produce static charges. An English experimenter built a hydro-electric machine based on this principle 100 years ago for the definite purpose of producing static charges.

Transmission Lines

91. A long electric transmission line, from which the current has been turned off, will retain a residual "static" charge. When an electric charge is turned into a long line, it takes a certain quantity of current to charge the line itself, just as it takes a certain amount of water to fill a pipe line. When the current is turned off, the electrons remain on the line and may be drawn off as a static spark, the size

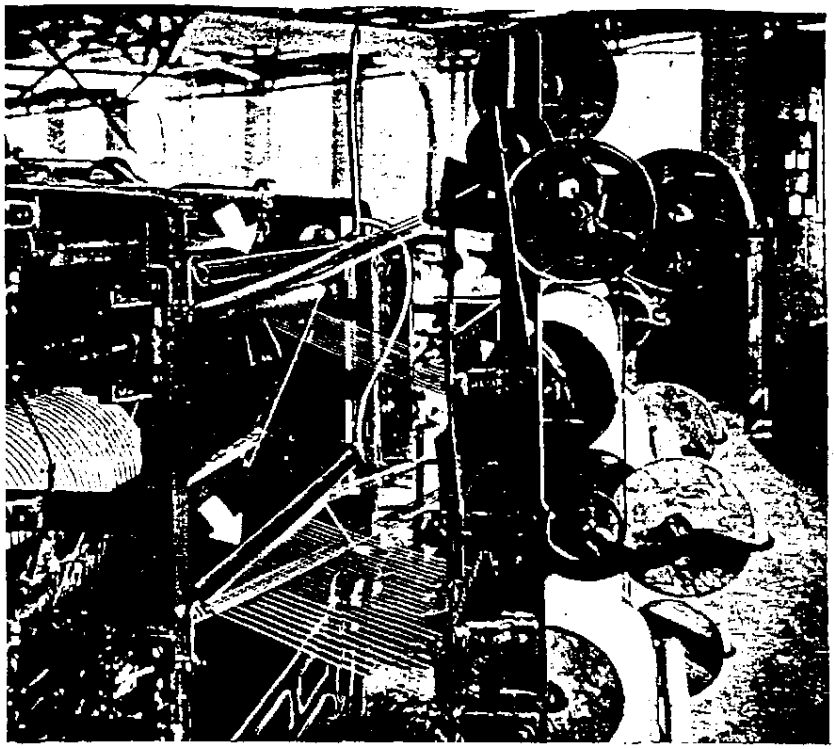
of the spark depending on the voltage and length of the line.

92. A transmission line may also become charged by induction and by wind friction. Cases have been reported where sufficient static has been built up on transmission lines during sandstorms to blow out the controls.

93. It is usual practice to ground transmission lines when they are out of service for any length of time and whenever any maintenance work is to be done. All important lines have permanent remote control grounding devices installed. Rules for grounding such lines are contained in the National Electrical Safety Code and the National Electrical Code.

Paint Spraying

94. Paint spraying generates static electricity. The object being sprayed should be supported in such a way as to avoid insulating it from a conductive surface. In a test, charges of 8,000 to 10,000 volts were built up on a non-conductive plate, but no charge was observed when a metal plate was used and grounded.



Courtesy Chapman Electric Neutralizer Co.

Figure 12. Static eliminator in use on textile machine. (See paragraph 87.)

Accumulation of Static on Persons

95. It is reported that a charge of 10,000 volts can be accumulated on a person's body by scuffing over a woolen rug or other insulated floor covering in a dry, cold atmosphere. Should flammable vapors, dust or gases be present in explosive mixtures, an explosion and fire may result if a spark should occur when the charge goes to ground.

96. Static charges collected by workmen can be controlled to some extent through the use of special-type footwear. Shoes that are well insulated by rubber soles, rubbers, or rubber boots, prevent the discharge of static electricity more so than leather, cord or other soles. Leather used in making soles tends to absorb moisture or perspiration and to some extent becomes a conductor and allows static to drain away. However, rubber cement used in manufacturing some leather shoes reduces the conductivity of leather soles. In some cases, shoes are made with non-sparking nails or rivets extending through the sole to increase conductivity.

97. Shoes with soles of electrically conductive rubber have been developed which are superior to ordinary leather shoes in respect to the dissipation of static charges. However, stockings made of wool or silk, or talcum powder in shoes, tend to nullify the value of a conductive shoe. Thin cotton socks are preferable to others in reducing body static. Conductive shoes are of most value where there is a conductive floor surface. Wax or other non-conductive floor finishings reduce the value of such a grounding measure.

98. Also, the effect of conductive shoes may be impaired by accumulations of foreign material on the bottom of the soles, as might happen should an employee walk across a waxed floor or work in an area where the floor is covered with French chalk or similar substances.

99. To determine the effectiveness of footwear in the control of static sparks, daily inspections are important. Such inspections may be visual to see that employees are wearing the correct type of socks or to observe the condition of the soles. Preferably, however, the inspection should be made with instruments. (See Figure 13.) This also applies to checking the conductive rubber tires on dollies and trucks.

100. It is good practice to provide some means of automatically grounding employees before they enter areas that may contain explosive mixtures. One arrangement consists of a short flight of steps provided with a grounded handrail, so located that the employees will use it to aid themselves in ascending the stairs. Another method is to install a grounded metal self-closing gate that the employee must open to enter the area.

101. To guard against accumulation of static charges by workmen:

a) Employees' footwear should be of conductive type.

b) Electrically conductive flooring, metal plates or floor mats of conductive material should be used in and around the hazardous area, extending a distance sufficient to permit draining of any static charges from the workman's body before they reach the point where they are dangerous.

c) Increase the relative humidity of the room to 50 per cent or higher.

d) All metal equipment with which the workman may come in contact should be electrically grounded.

Humidity

102. It is important to remember that in heated buildings the air is almost always very dry in winter. If the outdoor temperature is 30 F, for example, the air cannot possibly contain more than about 2 grains of moisture per cubic foot, representing 100 per cent humidity. If this air is taken into a building and warmed to 70 F without the addition of moisture, the relative humidity becomes only 25 per cent, which is bad from the standpoint of health as well as static. The heating and ventilating equipment of every building should contain means for humidifying the air. Otherwise, open pet cocks can be fitted into the steam pipes or radiators. (See Figures 11 and 14.)

103. It takes a surprisingly large amount of moisture to humidify air properly in cold weather. If outside air at 0 F and 50 per cent humidity is heated to 70 F, about 3½ grains of moisture per cubic foot must be added to maintain the same relative humidity. In a room 100 feet square and 12 feet high, with four changes of air per hour, over 28 gallons of water per hour are required.

104. The report of the N.F.P.A. Committee on Static Electricity states that the maximum relative humidity in the workroom which can be maintained without fogging or condensation on the inside of window panes is as follows:

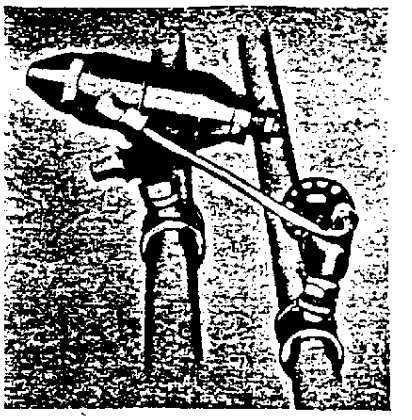
Outdoor Temperatures °F	Relative Humidity Single Windows	Double Windows
0°	15%	48%
10°	20%	53%
20°	27%	59%
30°	36%	66%
40°	47%	73%
50°	60%	81%
60°	78%	90%

105. It is easy to measure the humidity of any room with a wet and dry bulb thermometer. Safe Practices Pamphlet No. 37, "Industrial Ventilation," contains a chart showing the relative humidity corresponding to various wet and dry bulb temperatures, and the corresponding quantity of moisture in grains per cubic foot of air.

106. The degree of conductivity of surfaces having low conductivity depends on the relative humidity. One authority states that four grains of moisture per cubic foot of air disposed of static electricity in a rubber factory. Assuming a room temperature of about 70 degrees F., this quantity of moisture means a relative humidity of 50 per cent. This degree of humidity was likewise found sufficient to keep down static difficulties by another company handling flammable material.

Preventing Explosions

107. Sometimes it is impossible to prevent the occurrence of static sparks. Hence, it is always desirable, if possible, to remove the hazard by making it impossible for an explosive mixture of vapors, gases, or dusts to be present, as well as to eliminate all sources of ignition.

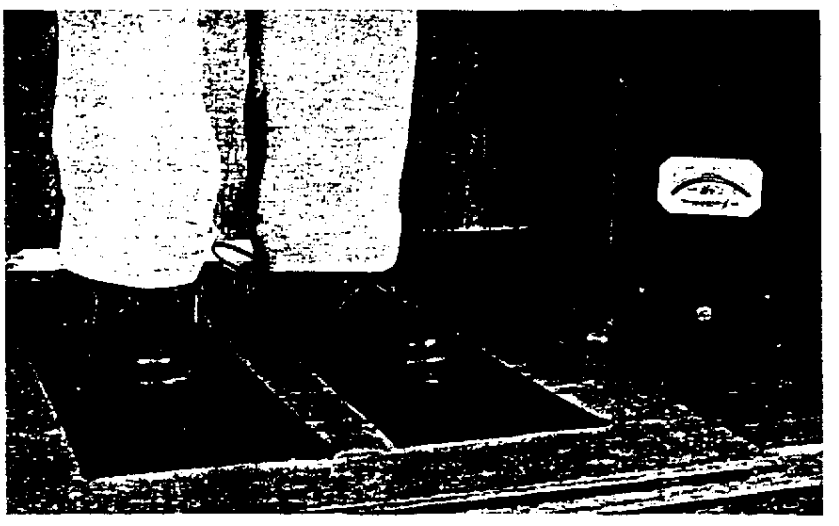


Courtesy R. I. Humidifier & Ventilating Co.

Figure 14. Humidifier—coupled to water and air lines. (See paragraph 102.)

108. In the textile, dry-cleaning, and other industries where volatile solvents are used, a process has been developed for drying out flammable solvents in an atmosphere of carbon dioxide and other gases instead of air, the oxygen being kept below the percentage necessary to form an explosive mixture.

109. In handling pulverized or finely divided materials, the explosion hazard may be reduced by providing equipment to exhaust such materials. This, like other methods mentioned in this section, removes the hazard, whether caused by static or by the presence of some foreign object, by preventing the accumulation of an explosive concentration. Fires and explosions are sometimes ascribed to static, which actually were caused by some hard or metallic object striking a spark when passing through grinding rolls, conveyors tubes, exhaust ducts, etc.



Courtesy The Procter & Gamble Defense Corp.

Figure 13. Testing shoes with conductivity indicator. (See paragraph 99.)

ACKNOWLEDGMENT

This pamphlet has been revised by the Industrial Department, National Safety Council, and has been reviewed by the Safe Practices Conference Committee and a special committee on static electricity under the chairmanship of A. H. Nuckolls, Underwriters' Laboratories, Inc. Grateful acknowledgment is made to the National Fire Protection Association for permission to use data and illustrations from the report of its committee on static electricity.

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