ELE
International

Operating Instructions

CORROSION MAPPING SYSTEM

Model: 35-2165 (CT-325)

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I. GENERAL INFORMATION

Half-cell potential measurements serve as an important means of determining the probability of corrosion activity on the structure reinforcing steel. These measurements, which are related to the electrochemical nature of corrosion, allow an accurate survey to be performed in a short period of time.

Data from these surveys can be plotted to provide an easy-to-interpret graphic picture of the structure. From these plots, probable corrosion areas and the total area of the structure subject to corrosion can be determined.

The 35-2165 (CT-325) **Corrosion Mapping System** consists of a voltmeter, a portable surfactant reservoir with electrode, 250 ft. (76 m) test wire with a hand reel, an adaptor plate, two 15" (381 mm) long electrode extensions, copper sulphate crystals, anti-freeze and concentrated surfactant solutions. Ideally suited for use on bridge decks, concrete piers and docks, highway slabs and parking garages, the **Corrosion Mapping System** is packaged in a convenient carrying case for easy transport.

II. RELATED USER DOCUMENTATION

These operating instructions do not contain all the necessary information on the specific test procedures. Please refer to ASTM C-876 for additional testing information. Additional references include:

Corrosion and Cathodic Protection of Steel Reinforced Bridge Decks. D. Burke and J. Bushman, Corrpro Companies Inc.

Proceedings of the Corrosion/87 Symposium on Corrosion of Metals in Concrete. NACE Publication No. 52169

RP 0187-87 NACE Standard Design Considerations for Corrosion Control of Reinforced Steel in Concrete. NACE Publication No. 53063

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III. PRECAUTIONS

A. A direct electrical connection to the reinforcing steel is required.

B. Because of the methods used to interconnect reinforcing steel, the reinforcing grid may not be electrically interconnected throughout the deck or structure.

C. Do not conduct or attempt testing of any kind when electrical welding is in progress, as might be the case where repair or renovation work is being done concurrently with the scheduling of this testing.

IV. PREPARATION OF CONCRETE SURFACE

A. Use a measuring tape to lay out a grid pattern of the test locations, typically on four foot centers covering the entire area which is to be tested. (Tests do not have to be made directly over the re-bars.)

B. Mark each test location with spray paint.

C. Making a spot of about two square inches, remove all asphalt, waterproofed surface or insulating films from each test location. (The surface scarifying which is usually done to many bridge decks during repair and/or renovating will usually suffice.)

D. Wet all test points with the electrical contact solution prior to testing. The location must still be damp at the time of actual testing.

E. Completely expose a few inches of one rebar in each bridge deck panel or structure section. Use a chisel or a file to clean the rebar down to bright metal.

1. This exposed area will be used as a connection point for tests to be made on the panel.

2. A rebar already exposed because of spalling may be used as a connection point, after appropriate preparation.

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V. PREPARATION OF NEW REFERENCE ELECTRODE

Prepare Copper-Copper Sulphate electrode a day ahead of scheduled testing to allow time for the porous plug to become thoroughly saturated with the copper sulphate solution.

A. Unscrew the top of the new electrode and fill it to the top with distilled water or anti-freeze solution. Screw the top on lightly (Hand Tight Only!).

B. Shake electrode for a couple of minutes and then make sure that some un-dissolved copper-sulphate crystals are still in the tube. If not, remove the electrode top and add some more crystals. (It is not possible to have too many crystals.)

C. Do not remove the plastic protective cap from the porous plug assembly on the bottom of the electrode until ready to use.

VI. PREPARATION OF SURFACTANT RESERVOIR

A. Remove the surfactant reservoir cap with the Copper-Copper Sulphate electrode attached.

B. Affix the solution dispensing sponge firmly to the bottom of the surfactant reservoir decanter.

C. Fill the container, approximately 3/4 full with the prepared electrical contact solution.

1. Such a solution would be composed of a mixture of 95 ml of wetting agent (commercially available wetting agent) or a liquid household detergent thoroughly mixed with 5 gal. (19 l.) of potable water.

2. Under working temperatures of less than about 50^{o} F (10^{o} C), add approximately 15% by volume of either isopropyl or denatured alcohol to prevent clouding of the electrical contact solution since clouding may inhibit penetration of the water into the concrete to be tested.

D. Upon filling, install the surfactant reservoir cap with electrode on the decanter as quickly as possible and hand tighten snugly. Initially some

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excess solution may dispense through the sponge until a vacuum is created inside the surfactant reservoir container.

NOTE: While handling and using the electrode assembly, always keep it in an upright position. See precautions on MSDS in handling Copper-Copper Sulphate Crystals and MCM Antifreeze Solution.

E. Mount assembly onto voltmeter.

1. Remove the brass thumbnut from the top of the electrode and screw the electrode into the bottom of the Intermediate Electrode Extension.

2. Screw the Intermediate Electrode Extension into the white fitting on the bottom of the Adapter.

3. Press the voltmeter firmly onto the top of the Adapter, mating the Velcro pads on the Adapter to the feet on the bottom of the meter's formica case. Make certain that the black wire on the Adapter is routed between the bottom of the feet of the meter.

4. Plug the black banana-plug into the black negative (-) terminal of the voltmeter.

VII. CONNECTION TO REBAR

A. Clamp vice-grip pliers onto previously exposed rebar in the panel being tested.

B. Clamp one end of the 250 foot (76 m) test lead to the vice-grip pliers.

C. Plug the other end of the 250 foot (76 m) test lead into the positive (center red) terminal on the voltmeter.

D. Repeat this procedure for each panel of the structure. This connection must be to a rebar in the panel being tested.

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VIII. OPERATION OF VOLTMETER

A. Place the function switch to the DC position.

B. Place the range selector switch to the 2V scale.

C. Place the input resistance selector switch to the 25 meg-ohm position.

IX. MAKING THE POTENTIAL MEASUREMENT

A. Place the reference electrode assembly against the prepared location on the concrete surface adjacent to the marked spot.

B. A steady reading (measurement) between -0.010 and -0.600 volts should be obtained on the meter within 3 to 5 seconds if the electrical connection to the rebar is good and if the concrete and interface sponge are wet enough.

C. Consider as normal a slight variation in the last digit (thousandth place).

D. If the test setup is working satisfactorily, it should be possible to go back to a location and obtain an identical reading within $\pm$0.020V of the original reading.

X. RECORDING THE POTENTIAL READINGS

A. Round off the potential reading to the nearest 0.01 volt.

B. For convenience, enter the reading on a data sheet laid out in a grid pattern to approximate scale similar to the bridge/structure panel being tested. (See Figure 1 for a typical drawing.)

XI. INTERPRETATION OF READINGS

A. Potentials less negative than -0.20 volts generally indicate that a 90% or higher probability of no corrosion is taking place at the time of measurement.

B. Potentials in the range of -0.20 to -0.35 volts are inconclusive.

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C. Potentials greater than -0.35 volts generally indicate that a 90% or higher probability of active corrosion is in that area at the time of testing.

D. Positive potentials (negative sign not displayed), if obtained, generally indicate insufficient moisture in the concrete and should not be considered valid. However, stray DC currents may also cause positive potential measurements and therefore careful review and analysis of the obtained data is required.

XII. SUGGESTED FORMAT OF COMPLETION REPORT

Following the completion of the field work, prepare a report to include at a minimum the following:

A. Equipotential contour map to approximate scale with all potentials plotted and contours drawn through points of equal or interpolated equal values. Maximum contour intervals should be 0.10 volts.

B. Estimated temperature of copper sulphate reference electrode during testing.

C. Method of pre-wetting the concrete.

D. Method of attaching test leads to rebar.

E. Percentage of readings in each panel or section that are more negative (-) than -0.35 volts.

F. Percentage of readings in each panel or section that are less negative (-) than -0.20 volts.

G. All positive readings (if any obtained) and their exact location, as plotted on the contour map

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XIII. SPECIFICATIONS

Meter:

Display	LCD; 3-1/2 digits, 0.5" (12.7 mm) h.	
DC Volt Range	0-20mv (0.01 mv resolution); 0-200mv (0.1mv resolution); 0-2v (1mv resolution); and 0-200v (0.1v resolution); ±1 digit or 1% of reading accuracy	
AC Rejection	20mv range:	20mv AC at 50/60/400Hz
	200mv range:	5v AC at 50/60/400 Hz
	2v Range:	120v AC at 50/60/400Hz
	200v range:	600v AC at 50/60/400 Hz
Input Resistance	20mv range:	1000 ohms. All other DCv ranges are switch seleactable (10, 25, 50, 100, 200 megohms).
Battery	One 9v alkaline recommended	
Dimensions	6-1/8" x 3-5/8" x 1-3/4" (15 x 8 x 4.5 cm)	

Other Components: Adaptor plate; two 15" (381 mm) long electrode extensions; surfactant reservoir with electrode; 250 ft. (76 m) test wire with hand reel; copper sulphate crystals; anti-freeze and concentrated surfactant solutions; and manuals

Case Dimensions: 18.24" w. x 7.75" d. x 14.5" h (463 x 197 x 368 mm)

Weight Net 14 lbs. (6.3 kg)

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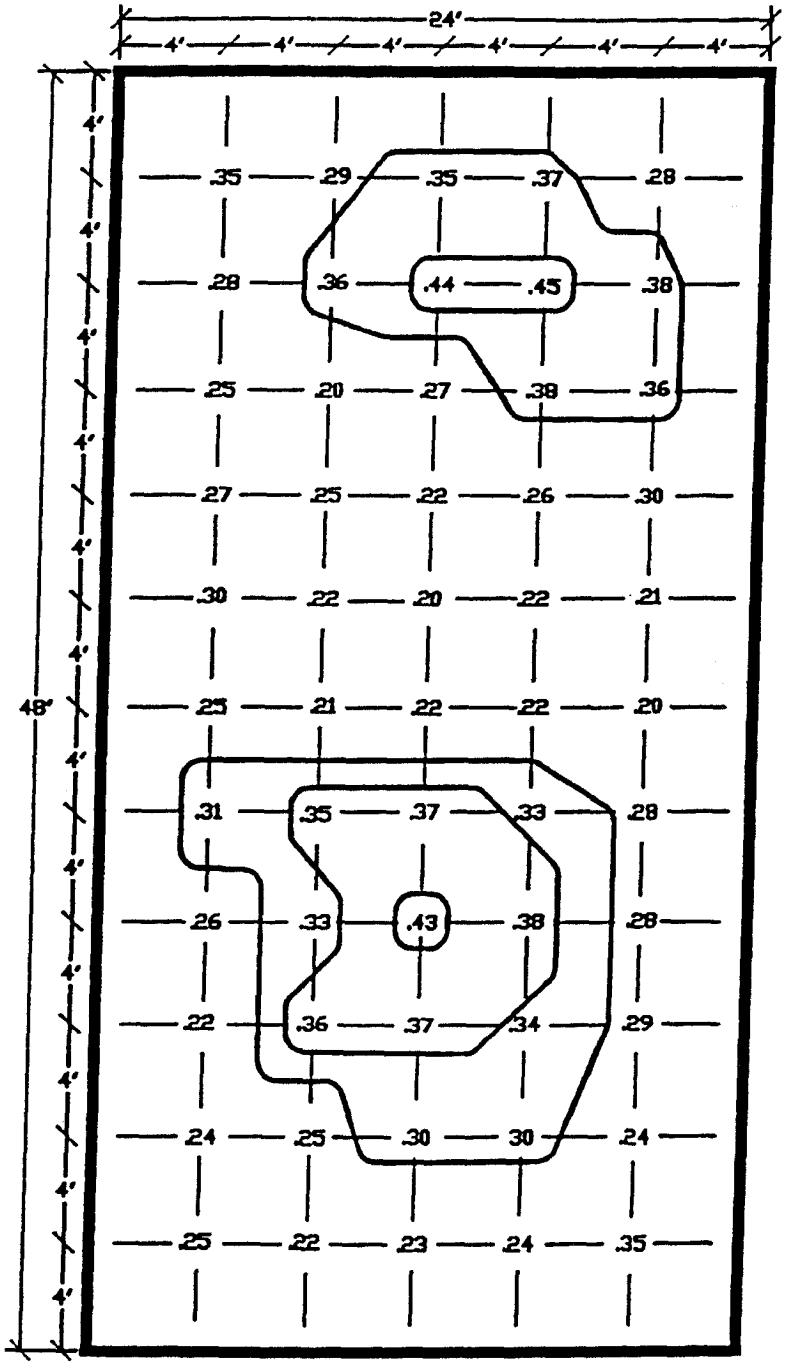
FIGURE 1
Typical Concrete Slab with Reinforcement (Rebar)



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VOLTMETER REFERENCE GUIDE

I. FEATURE DESCRIPTION

A. Use of Input Resistance Selector Switch

(Functions only on DC and AC Voltage ranges 200 mv and up.) This switch is normally left in the 10 megohm position. When the meter is used in conjunction with one or more reference electrodes, we recommend the following procedure for detection and elimination (usually) of errors caused by high electrode contact resistance:

1. Take reading with input resistance switch on 10 megohm range.

2. Rotate switch to 25M range; take reading. If reading is the same as in 1, record reading. If reading is higher than in 1, switch should be rotated until same reading is obtained on two adjacent sensitivity positions. For example, if the following readings were obtained:

Reading	Sensitivity Setting
0.88	10 megohms
0.89	25 megohms
0.90	50 megohms
0.90	100 megohms

then the .90 volt reading would be correct.

3. If reading increases when switch is rotated from 100M position to 200M position, then it is not possible to get an accurate reading without obtaining a better contact between the electrode and the soil. This can usually be accomplished by digging the electrode into the soil or by watering the soil at the point of electrode contact.

Precaution: It is essential that insulation on the test lead wire between the meter and the electrode be free of cracks or pinholes; otherwise, leakage errors may occur, particularly in those locations where it is necessary to use the higher sensitivity settings in order to obtain a reading.

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NOTE: Use of either the 200 or 10 megohm range in conjunction with the 200mv range is not recommended. Use the 2V or 200V range if input resistances greater than 50 megohms are required.

B. Use of Push-to-Hold Button

1. The push-button located on the right side of the panel below the display functions to freeze whatever is being displayed. The holding or freezing action continues until the button is released.

2. This feature is especially useful in areas where varying stray currents are encountered, since it is difficult to interpret a digital read-out, which is continually changing.

3. When taking coordinated readings at a number of locations at the same instant by using a network of two-way radios, the push-to-hold button provides an excellent way to ensure simultaneous readings. The group leader instructs each person to read his meter when he says "mark" at which time each person depresses his push-to-hold button until he has had time to enter the reading on a data sheet.

4. Another increasingly important use for the push-to-hold button is for obtaining so-called "instant off" readings of polarized potentials on a structure. (See "Instant Off Potential Measurements," Sec. III, B pg. 12.)

C. Use of Adapter Plate

1. The adapter plate mounts by means of Velcro pads, without use of tools, to the bottom of the meter case.

2. The adapter plate provides a 1/4"-20 female electrical and mechanical connection into which an intermediate electrode extension is screwed.

3. Copper sulfate reference electrodes can be screwed into the female end of the intermediate electrode extension to obtain a rigid, watertight connection.

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4. Additional intermediate electrode extensions, each 30" (762 mm) long, can be added to provide a greater distance between electrode and meter.

D. Use of External Shunt

1. External shunts (other than those specifically made for this voltmeter) require a pair of wires to be connected between the common (-) and center (+) meter terminals and the potential terminals of the shunt.

2. Depending on the particular shunt, the 20mv or 200mv range would be employed.

II. USE OF METER

A. DC Potential Measurements

1. Turn range switch to 200V range.

2. Turn function switch to DC.

3. Turn power switch to 10 meg position. Display should turn on and within a few seconds indicate "000". If "Lo Bat" appears in the display, then the 9V battery must be replaced as soon as possible.

4. Connect test leads to common (-) and center (+) terminals.

5. Turn range switch to a lower range if necessary to obtain a more detailed reading. If polarity at input is opposite to that marked on panel, a "-" sign will appear in the digital display. When the display shows "1" followed by blanked digits, the input is higher than full scale. Use higher range if available.

6. Use input resistance selector switch as necessary to detect and minimize effects of high resistance in the external circuit. (See "Use of Input Resistance Selector Switch").

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B. AC Potential Measurements

1. Turn range switch to "600V AC", turn function switch to AC position, then connect the test leads to the (-) left and (+) center input terminals of the meter.

2. The input resistance selector switch is functional on the 600V AC range and can be used to detect and eliminate errors caused by high resistance in the external circuit. (See "Use of Input Resistance Selector Switch".)

3. Do not energize the voltage source, if over 50V, at the time test leads are being connected. Do not touch bare parts of the banana plugs or test clips when measuring line voltages. Make sure that the test leads have an adequate insulation rated at 600V or more.

4. When measuring structure-to-soil AC voltages, contact to the soil may be made with any metal rod or a copper sulfate reference electrode can be employed.

5. If soil is very dry, is frozen, or consists of mostly gravel, it may be necessary to use the input resistance selector switch (right switch) to check for and eliminate contact resistance errors. (See "Use of Input Sensitivity Switch".)

Caution: Always disconnect test leads from AC voltage source before turning either the range switch or function switch to another position. Failure to do so may result in damage to the meter!

C. Use of Meter in Stray Current Areas

1. The push-to-hold button on the voltmeter offers a way to obtain representative readings of varying DC currents.

2. One technique is to take and record a series of readings at intervals of perhaps 10 seconds, using the hold button each time. From this data, you will obtain approximate maximum, minimum, and average values.

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3. Another technique is to use a high sensitivity analog voltmeter connected in parallel with this voltmeter. The analog meter indicates trends, and therefore suggests when to push the hold button to obtain the readings desired.

III. POTENTIAL MEASUREMENTS

A. Surface Potential Surveys

1. This type of survey employs two copper sulfate electrodes and is applicable to bare pipelines. No connection to the pipe is required.

2. The survey is conducted with both electrodes directly over the line at a fixed spacing of 10 or 20 feet. The survey is conducted with both electrodes directly over the line at a fixed spacing of 10 or 20 feet. Readings are taken of potential between electrodes at intervals matching the electrode spacing. The same electrode is always kept in front as the survey progresses. The front electrode is connected to the positive terminal. The readings will change polarity from + to - as an anode area is passed.

3. Supplementary side drain readings (one electrode over the pipe, the other electrode 5 ft. to one side) are taken as suspected anodic points. The reading is often repeated on the opposite side of the pipe as a double check.

B. Instant-Off DC Potential Measurements

1. To measure structure-to-soil potentials immediately after cathodic protection is turned off, depress the push-to-hold button and hold down the button as soon as it is perceived that the cathodic protection has been turned off. With a little practice, you can freeze the reading within approximately .5 seconds after cathodic protection is de-energized.

2. When there are several sources of cathodic protection current for a structure, all should be turned off at the same instant if meaningful "instant-off" readings are to be obtained. This normally means that a crystal controlled current interrupter must be installed at each cathodic protection installation. These should be synchronized within a fraction of a second.

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C. Resistance Measurements

1. Any resistance less than 200 ohms can be measured. The only precaution is to make sure that there is no pre-existing voltage in the circuit being measured. If there is a pre-existing voltage, a noticeable error will be produced. If the voltage is high enough, damage to the meter is likely Always check for existing voltage before measuring resistance.

2. The resistance range is very useful for checking resistance and continuity of test leads, test stations wiring, bond connections, etc. If the circuit is open (non-continuous), or if resistance exceeds 200 ohms, the display will show "1" followed by blank digits. To measure resistance, place range switch in "200 ohms" position, connect test leads to common (-) and (+) center banana jack terminals, turn function switch to "ohms" position.

D. URD Cable Tests

1. Underground Residentail Distribution cable (URD for short) typically has bare copper concentric neutral wires. There have been a large number of corrosion failures of these neutrals. In most cases, the attack is quite localized.

2. In order to prevent possible voltage hazards resulting from failure of the neutral, many power companies are surveying their URD cable.

3. Measurement of cable-to-soil DC potentials at intervals of as little as 2.5 feet is suggested. Since the presence of AC potentials may be a factor, it is suggested that AC potentials to soil should also be measured. IR drop tests from transformer to transformer will indicate magnitude and direction of DC currents along the neutral.

E. Bridge Deck Corrosion Surveys (ASTM C-876)

1. In areas where de-icing salts are used on highways in the winter, accelerated corrosion of the steel reinforcements (re-bars) often occurs.

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2. A potential survey (on 4 ft. centers) of the re-bars will provide useful data as to the presence or absence of active corrosion on the re-bars.

F. IR Drop Measurements

1. Because the 20mv DC range of the voltmeter has a resolution of .01 mv, it is ideally suited for measuring IR drops on metallic structures such as pipes, cables, guy wires, or structural members.

2. Before taking an IR drop reading, test the circuit for continuity by use of the 200 ohm resistance range. For accurate results on the 20mv range, the external circuit resistance should be less than 10 ohms. This should rarely present a problem since test station wiring normally measures less than 1 ohm. The positive test lead must be on the center terminal for the resistance test and must be moved over to the 20mv terminal for the actual IR drop measurement.

IV. MAINTENANCE

A. Battery Power Supply

1. All of the power required to operate this meter is obtained from one 9V battery. Replacement is required when the "LoBat" indication shows up in the display. The "LoBat" indication shows up only when the battery voltage drops below 6.8V. If battery is not replaced within a few hours, the meter will start to read high.

2. Carry a spare 9V battery so that a survey is not interrupted.

3. Although any 9V "transistor" battery will operate the voltmeter, the heavy-duty type, such as the Eveready #1222, is recommended. In cold weather, or when the resistance range is used often, an alkaline 9V battery, such as Eveready #522 or Mallory #MN1604 will have a longer life. If the meter is turned off at night, service life of a 9V battery should be about 3 months.

4. Access to the battery is obtained by removing the four panel screws.

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B. Temperature Limitations

1. Operating Range: 8 to 176^{o}F (-14 to 80^{o} C). Will tend to be sluggish at low end of temperature range.

2. Storage Temperature: -37 to 176^{o} F (-35 to 80^{o}C). Storage outside these temperatures limits may damage the liquid crystal display.

C. Cleaning Guidelines

1. Keep panel as clean and dry as possible for the best results.

2. Use a slightly moistened cloth to remove mud, after which the panel can be dried under a lamp or in the sun for a few minutes.

3. Avoid abrasive cleaning compounds or strong solutions, which might harm the panel

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V. TROUBLE SHOOTING

No display	Battery dead or disconnected. Replace battery.
Display partially or completely blackened.	Meter subjected to excessive temperature. Replace display.
No reading on AC range	Function switch in wrong position. Turn Function Switch to AC position.
Ohms range reads differently when leads reversed.	Circuit under test has voltage. Remove voltage supply from circuit.
No reading on 20mv range	Test lead on wrong terminal. Shift test lead from Volts/Ohms to + 20mv.
All readings high	Operator neglected to heed "LoBat" display. Replace battery without delay.
Display changes very slowly	Meter too cold. Keep meter in warm place, when actually taking a reading.
Display jumps erratically and is not correct.	Excessive RF from radio or TV transmitter. Move further away from transmitter.

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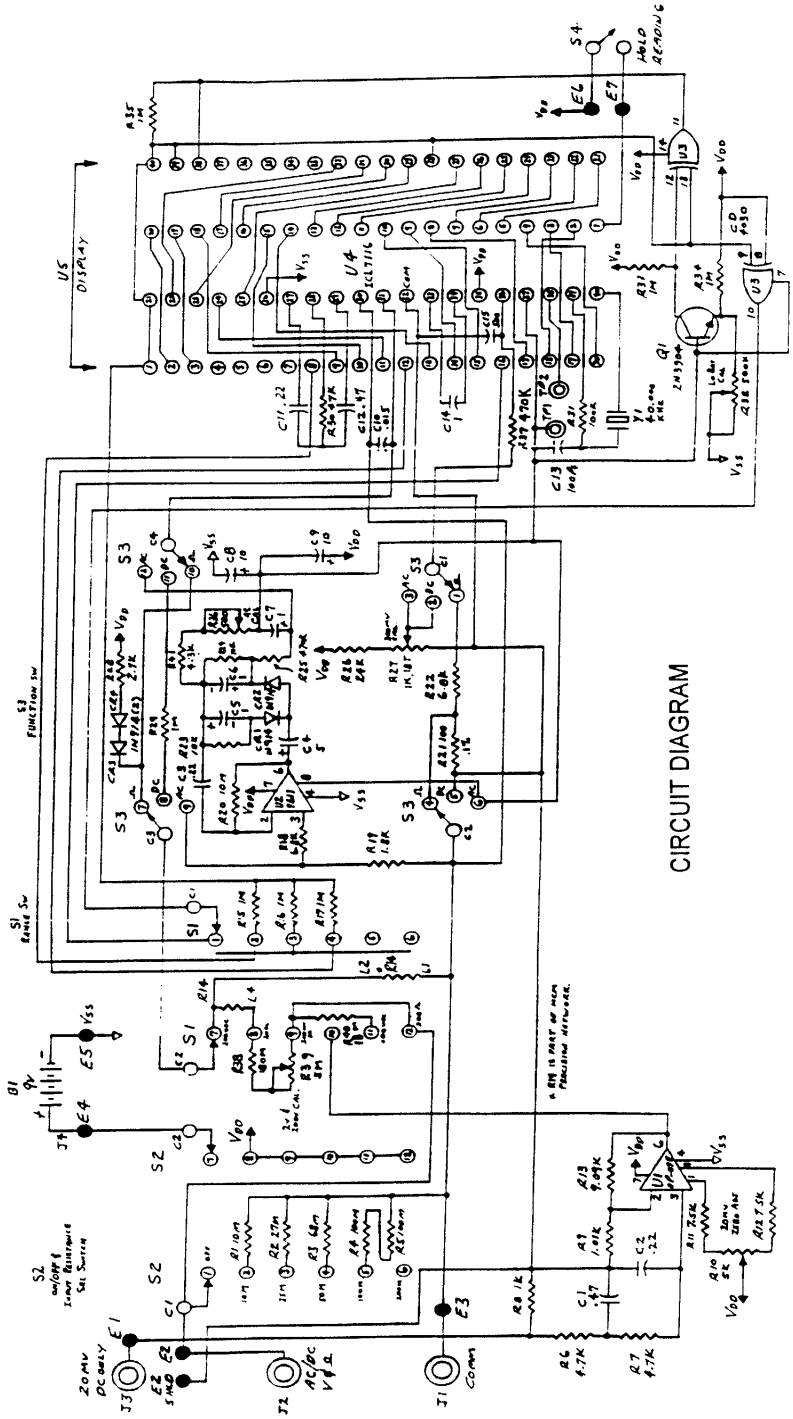

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MCMILLER Co.

MATERIAL SAFETY DATA SHEET

Dated: FEBRUARY 1990

SECTION I — IDENTIFICATION

Catalog Number: 17105 & 17207

Product Name ANTI-FREEZE SOLUTION

SECTION II — PRINCIPAL HAZARDOUS COMPONENTS

COMPONENT	PERCENT	HEALTH	REACTIVITY	FIRE	PERSISTENCE	CASE No.
Glycerin	25 - 75%	1	0	1	0	56-81-5
Cupric Sulfate	5 - 25%	3	0	0	3	7758-98-7
Distilled Water	10 - 25%	0	0	0	0	Generic

SECTION III — PHYSICAL DATA

BOILING POINT: 100°C
VAPOR PRESSURE, mm Hg: Not Determined
VAPOR DENSITY (AIR = 1): ND
SOLUBILITY IN WATER: Miscible
APPEARANCE: Light Blue Liquid

SPECIFIC GRAVITY (H2O = 1) 1.0
PERCENT VOLATILE: 0
EVAPORATION RATE: ND
pH: 5.0
ODOR: None

SECTION IV — FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: NA
SUSCEPTIBILITY TO HEATING: None
SHOCK SENSITIVITY: None

FIRE FIGHTING MEDIA: Dry Chemical, Carbon Dioxide
HAZARDOUS DECOMPOSITION PRODUCTS: Not Determined

SECTION V — HEALTH HAZARD DATA

EFFECTS OF OVEREXPOSURE:
EYES: Severe Irritation
SKIN: Mild Irritation and Itching
INHALATION: None
INGESTION: Salivation, Vomiting, Bloody Diarrhea

EMERGENCY FIRST AID:
EYES: Flush with Large Amount of Water for 15 - 20 Minutes
SKIN: Remove Clothing, Flush Skin with Water and Mild Detergent
INHALATION: Remove to Fresh Air
INGESTION: Induce Vomiting, CALL PHYSICIAN

SECTION VI — REACTIVE DATA

STABLE: Yes
CONDITIONS TO AVOID: None

HAZARDOUS POLYMERIZATION: Has not been Reported

HAZARDOUS DECOMPOSITION PRODUCTS: Toxic Gases

SECTION VII — ENVIRONMENTAL PROTECTION PROCEDURES

SPILL RESPONSE: SPILLS - Absorb with Vermiculite or Other Absorbent

WASTE DISPOSAL METHOD:

Under the Resource Conservation & Recovery Act (RCRA), it is the responsibility of the generater of the waste material to determine, at the time of disposal, whether the waste generated meets Federal or State Hazardous Waste Information criteria. Because uses, transformations, mixtures, processes, etc. may render the resulting material hazardous, consult Federal, State and local authorities for disposal information.

SECTION VIII — SPECIAL PROTECTION INFORMATION

EYE PROTECTION: Chemical Splash Goggles
RESPIRATORY PROTECTION: None
SKIN PROTECTION: Wear Impervious Clothing and Boots

VENTILATION RECOMMENDATIONS:
Provide Local Exhaust Ventilation

This information is believed to be accurate and represents the best information currently available to the M.C.Miller Co.,Inc. However, we make no warranty of merchantability or any other warranty, expressed or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purpose.

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