DIVISION 11

CORROSION CONTROL

11.1 General - This criteria shall be utilized in the design of corrosion control systems for new installations and/or maintenance and repairs to existing cathodic protection installations.

11.1.1 The design of new or refurbishment of existing cathodic protection systems shall be performed or supervised by a Corrosion Engineer. Corrosion Engineer refers to a person, who, by reason of knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control. Such people may be a licensed professional engineer or may be a person certified as qualified by NACE International, hereinafter referred to as NACE, if such licensing or certification includes suitable experience in corrosion control on buried or submerged metallic piping systems and metallic tanks.

11.1.2 This criteria is not intended to restrict creative engineering design. Should alternative materials or design concepts be deemed advantageous, they shall be presented to DFW Energy & Utilities Services for review and comment prior to approval.

11.2 Corrosion Control of Process System Equipment and Piping

11.2.1 Material Selection - All equipment and piping in the following systems shall incorporate appropriate corrosion control methods:

Boiler Feed Water	Waste Water
Steam and Condensate	Condenser Water
Potable Water	Fire Protection Water
Chilled Water	Gas and Compressed Air
Hot Water	Fuel Oil

In the above services, copper base or aluminum alloys must not be attached to ferrous materials, or to each other.

Where the interconnection of different metals is necessary, they shall be electrically isolated using approved dielectric materials, or the cathodic metal shall be required internally coated where isolation is not practical.

Material selection shall be reviewed by a Corrosion Engineer to insure that acceptable durability shall be achieved.

11.2.2 Corrosion Inhibitors and Additives - Process systems such as boiler feedwater, condensate, condenser water and chilled/hot water require the addition of chemical additives that help to reduce internal iron pipe or tank corrosion. Provisions shall be made for conveniently and safely injecting these inhibitors and additives in these systems for maintaining the required protective residuals. Provisions shall also be made for sampling these processes for testing of residual levels. All corrosion inhibitors or additives shall be specified by or approved by a Corrosion Engineer. These systems shall not discharge to the storm sewer.

11.2.3 Access for Inspection - All equipment that may be subject to corrosion, or may require periodic maintenance, shall have reasonable access for inspection.

Boilers shall be equipped with firebox doors and access openings to superheat and preheat sections.

Flue gas ductwork shall be provided with reasonable access openings.

Heat exchangers, coolers, condensers and evaporators shall be equipped with at least one

(1) removable head from where the tube sheets and tube ends may be inspected.

Corrosion inhibitors are not completely effective in preventing dissimilar metals (galvanic) corrosion. Water boxes shall be provided with protective coatings and cathodic protection whenever dissimilar materials of construction shall be used in direct aqueous contact.

Cooling towers shall be provided with sufficient access and ladders so that the basin, trays, mist section and fans can be inspected and maintained.

11.3 Miscellaneous

11.3.1 Electrical Grounding Systems and DC Powered Equipment - Buried electrical ground rods shall be stainless steel, stainless steel-clad or galvanized steel. Buried cable shall be insulated, and cable-to-ground rod connections shall be coated.

DC powered equipment shall be insulated from other structures so that no DC current flows through the earth to other structures.

11.3.2 Nonmetallic Materials - In some instances, metallic and non-metallic materials are acceptable for the same service. In general, preference should be given to the non-metallic material if its durability is approximately equivalent to that of the metallic material.

Immersed or buried composite structures such as steel reinforced concrete should be made electrically continuous by appropriate bonding between sections. A minimum of two (2) inches of concrete shall cover all ferrous materials used as reinforcement

11.3.3 Design Life - The following criteria have been established as a guide:

A maximum internal corrosion rate of one (1) mil per year based on maximum depth of penetration is acceptable to permit realization of at least fifty (50) years service life free from major replacements for piping systems.

Corrosion control of exterior surfaces of equipment, piping, structural and miscellaneous steel shall be accomplished by providing a high-quality paint system. Buried piping and fittings shall be protected by electrically insulating coatings supplemented with cathodic protection. Concrete encasing shall not be an alternative to coating or cathodic protection.

11.4 Painting - In general, surfaces of equipment, piping, structural and miscellaneous steel shall be painted with a protective coating. All surfaces shall be primed with a final coat applied in the field. Aluminum, stainless or galvanized steel shall not be painted except as indicated otherwise.

11.5 Underground Piping Systems Protective Coatings - All buried, pressurized, ferrous metal piping systems (except pre-insulated pipe) shall be externally protected with a bonded pipeline type system of high dielectric strength. The purpose of this coating is to isolate the pipe from the soil.

11.5.1 Cast iron and ductile iron pipe, fittings, valves and fire hydrants shall be coated specifically with twenty (20) to thirty (30) mils (dry) of a pipeline quality asphalt-based coating equivalent to Royston R-28. In areas where the possibility of soil contamination by jet fuel exists, a mastic coating combining coal tar with asphalt materials equivalent to Royston A-51 Plus shall be applied to the fitting to the same thickness. Coatings with one hundred percent coal tar mastics are incompatible with the asphalt primers found on the fittings, and are therefore not acceptable.

11.5.2 Field joint repair on jet fuel lines shall be coated with a mastic coating equivalent to Royston A-51 Plus, two-component systems such as coal tar epoxy or the pipe coating manufacturer's recommended repair coating. All coatings submitted for approval must have documentation on coating characteristics and application thickness.

11.5.3 Unbonded or loose fitting coatings such as poly bagging are not approved coatings. Equivalent coatings shall be reviewed by DFW Energy & Utilities Services for approval.

11.6 Cathodic Protection - The airport utilizes both impressed current and galvanic anode cathodic protection systems (CPS) to supplement coatings used for corrosion control. Impressed CPS shall have a design life of greater than twenty (20) years. Maximum design life for galvanic anode systems utilizing magnesium or zinc anodes is greater than fifteen (15) years. Cathodic protection systems for immersed service shall be designed for a minimum ten (10) years. In all cases, provisions shall be made for replacement of anodes and reference electrodes.

11.6.1 The selection of the type cathodic protection system to be employed, shall be specified by a Corrosion Engineer following preparation of preliminary piping layout drawings. Such selection shall be reviewed by DFW Energy & Utilities Services for approval.

11.6.2 All buried pressurized or immersed ferrous metal piping systems (except pre-insulated pipe) shall be properly coated, electrically isolated, bonded if necessary, and cathodically protected to prevent electrolytic corrosion.

11.6.3 Systems to be protected include but are not limited to:

Jet Fuel Lines
Natural Gas or Heating Fuel Lines
Potable Water Lines
Compressed Air Lines
Waste Oil Storage Tanks and Piping Systems
Hydraulic Elevators/Lifts and Piping Systems
Interior of Aboveground Water Storage Tanks
Fire Protection Water Lines
Pneumatic Lines
Underground Fuel Storage Tanks and Appurtenances

11.6.4 Impressed current anodes shall be located to minimize stray current pick-upon on unprotected or foreign metal structures. Care shall be taken to not place impressed current anodes near prestressed concrete pipe or reinforced concrete pipe, which could be damaged by excessive levels of cathodic protection current.

11.6.5 A sufficient number of test lead wires shall be installed on ferrous metal structures such as pipelines, so that interference situations can be analyzed and corrected. Cathodic protection interference problems and their solutions are rarely similar, precluding “rigid” or ”set” specifications for mitigation. Multiple structures in an area of interference can be very complex, requiring extensive coordinated testing under the direction of a Corrosion Engineer.

11.6.6 Protective Potentials

11.6.6.1 Ferrous Metals - NACE Standard RP 01 69-92 shall be used to determine protective potentials for ferrous metals. While this Standard lists three (3) primary criterions’ as acceptable, the DFW Airport has selected only (1) one that will meet their requirements.

The method selected for determining a protective potential shall be as follows:

A negative polarized potential (immediate “off” potential) of at least 850 millivolts relative to a saturated copper-copper sulfate reference electrode.

Soil contact points (pavement inserts) over ferrous structures such as welded pipelines, valves and fittings shall be placed at intervals of fifty (50) feet in areas where concrete or asphalt pavements prevent direct contact with the soil. If necessary, a more definitive spacing shall be determined on an individual basis by a Corrosion Engineer, where external factors that have an adverse influence on the line. Soil contact points shall be a molded polyethylene pavement insert 1-¾ inches in diameter by six (6) inches long.

Where temporary placement of a reference electrode in soil directly over the structure is not possible, a copper-copper sulfate permanent reference electrode shall be considered for installation.

11.6.6.2 Non-Ferrous Metals - Protective potentials for nonferrous metals shall be established by a Corrosion Engineer and shall be in accordance with NACE Standard RP 01 69-92. Specific references can be found in Section 6 - Criteria and other considerations for cathodic protection.

11.6.7 Galvanic Anodes

11.6.7.1 Galvanic anodes shall be installed at all isolated fittings such as 45's, 90's, T's, gate valve's and fire hydrant's, clusters of up to four isolated fittings located within ten (10) feet of each other, short piping sections, small, well-coated structures and in areas where interference with other structures might result from the use of impressed current systems. The anodes shall consist of a galvanized steel cored, magnesium or zinc rods packed in cloth bags containing a specially prepared backfill material.

11.6.7.2 All galvanic anodes shall be attached to the structure requiring protection through the connection of the anode lead wire to a calibrated 0.1 ohm shunt to one (1) of the structure lead wires that are thermite welded to the structure. The top of all galvanic anodes are buried a minimum of twelve (12) inches below the structure either vertically or horizontally.

11.6.8 Impressed Current Systems

11.6.8.1 General - Impressed current systems shall consist of transformer-rectifier power sources, anodes placed in suitable backfill, and appropriate wiring to connect the rectifier(s) to the structures and the anodes. A complete, coordinated system must be provided.

11.6.8.2 Rectifier - The rectifier(s) selection shall be based on the field survey data and design calculations performed by a Corrosion Engineer during the design phase of the project. The rectifier shall be selected to operate at efficient settings, but shall provide surplus capacity for reasonable future expansion. As a minimum, provide approximately twenty (20%) percent surplus capacity for protected structures.

The rectifier shall contain internal circuit breakers, an output ammeter and voltmeter, and shall be mounted in a suitable cabinet or enclosure.

All rectifiers shall be provided with a properly sized, NEMA 3R rated A.C. service breaker, which shall be placed in close proximity to the rectifier.

11.6.8.3 Anodes - Impressed current anodes shall consist of either high silicon, chromium-bearing cast iron or linseed oil treated graphite, complete with high molecular weight polyethylene lead wires installed with the cable-to-anode connection properly sealed or encapsulated by the anode manufacturer. Specialty anodes shall be approved by a Corrosion Engineer if conditions require their use.

11.6.8.4 Ground Beds - Anodes are installed in drilled, augured or trenched holes at depths commensurate with soil resistively, water tables and the structure geometry. Anode holes shall be filled with the required quantity of a well compacted granular, low resistance coke breeze backfill, as specified, installed so as too uniformly surround the anode.

Where the groundbed is to be installed under concrete or asphalt, the anode holes shall be vented to permit the release of gas generated at the anode surface. Backfill above the coke breeze shall consist of pea gravel to assist in venting of generated gases and to permit percolation of water.

11.6.9 Electrical Isolation And Bonding

11.6.9.1 Electrical Isolation - Structures requiring protection may require isolation from other underground metals by physical separation or by suitable dielectric materials. Above ground

piping, fittings or equipment requires electrical isolation from underground connected and cathodically protected piping, fittings or other structures by the use of isolating pipe flanges.

In general, dielectric fittings shall be installed to be accessible after backfilling. The preferred location is on the vertical riser twelve (12) to twenty four (24) inches above grade, before wall penetration into a building. If it is not practical to install the isolating fitting in an accessible location, one (1) set of two (2) test wires shall be thermit welded to each side of the isolating fitting and extended to an at-grade test station to facilitate testing. The cathodically protected side of the isolating fitting shall have white test lead wires, the unprotected side shall have green test lead wires.

When necessary to install dielectric fittings inside a building, the pipeline shall be isolated from reinforcing steel, masonry, concrete, etc. by passing through a non-conducting sleeve of plastic, or a metal sleeve with an insulating modular rubber seal to support, center and isolate the pipe from structural steel. Dielectric fittings should be inside the building as close as practical to the building wall. These points shall be accessible for inspection and repair.

Where it is necessary to interconnect dissimilar metals underground, dielectric fittings shall be installed at the connection point. All buried insulating fittings shall be coated with an approved coating material equivalent to Royston R-28, A-51 Plus or Mavor Kelly B-50. Final decision of proper coating shall be made by a Corrosion Engineer. Painting of above-grade insulating fittings shall be done with electrically nonconductive paints. Aluminum or zinc-rich paints are not approved for this application.

All pipes entering meter vaults, penetrating building floor slabs and building walls shall be sleeved with modular rubber links to electrically isolate the pipe from contact with building/vault steel. The modular links shall be equivalent to Thunderline Link-Seals.

11.6.9.2 Bonding - Insulated copper cables for reinforced concrete cylinder pipe shall be welded or brazed across all mechanical joints in underground ferrous piping systems and at all isolated ferrous metal fittings such as 45's, 90's, T's, gate valves and fire hydrants that will be cathodically protected. Bolted connections are not acceptable.

Bonds shall consist of a #8 stranded copper wire with HMWPE insulation and shall be 12 - 18 inches in length with ample slack after all welds have been made.

Bonds may be installed between adjacent or crossing piping systems to allow protection of several systems from the same current source. Drain bonds shall be installed on any structures that may be subject to cathodic interference effects.

In the area of influence of an impressed current groundbed, reinforcing steel in buried nonmetallic structures should be bonded so that the structure is electrically continuous. These structures include reinforced concrete pipe, prestressed concrete pipe and reinforced concrete cylinder pipe.

11.6.9.3 Casings - When a cathodically protected pipeline passes under a roadway, runway or taxiway, it shall be placed inside a casing if required for mechanical strength. The carrier pipe (cathodically protected pipe) shall be electrically isolated from the casing. Casing insulators shall be specified for installation on the carrier pipe prior to placement in the casing.

Casings or rigid galvanized conduits shall be provided for all cathodic protection header cables under a roadway, runway or taxiway.

Casing end seals shall be specified to prevent moisture from entering either end of the casing.

Casings shall not be coated. Ferrous metal carrier pipes inside the casing shall be coated with the same quality coating as is applied to the remainder of the piping system. Ferrous metal casings shall cathodically protected. Utilization of PVC casings is encouraged.

Test stations shall be installed at one (1) end of each ferrous metal casing containing a cathodically protected pipe. Specify the test leads for the end of the casing that will be most accessible for future testing. Each test station shall have two (2) white insulated lead wires from the carrier pipe and two (2) red insulated lead wires from the casing.

11.6.10 Test Stations - Test stations shall be installed flush to grade in a concrete slab, at predetermined locations to facilitate inspection of the system. Two (2) test wires shall be connected to each buried structure or cluster of fittings by thermit welding and brought to the surface in an appropriate terminal box. All test stations shall be filled with clean native soil free of rocks, asphalt or concrete.

11.6.10.1 When foreign structures are adjacent to protected structures, test wires shall be attached to both structures to facilitate interference testing and/or mitigation bonding, if necessary.

11.6.10.2 Aboveground test stations shall be specified wherever their use is permissible and will not conflict with aircraft or vehicular traffic. At-grade test stations shall be specified in locations where aboveground test stations are not appropriate.

11.6.10.3 Non-AOA Test Stations - All test stations installed that are not in the A.O.A., shall have a lockable cast iron lid with the cast-in legend “C. P. Test”. A nonmetallic extension tube (minimum length of eighteen (18) inches), shall be attached to the head of each test station. Provisions shall be made for connecting the anode and structure lead wires inside the test station on a nonconductive terminal board.

11.6.10.4 AOA Test Stations - Test stations for installation in the A.O.A. shall be an L-868 Class II Ground Support Light Base by Crouse-Hinds, Inc. or equivalent. The fixture shall include and adjustable base sufficiently long to extend through the concrete and into native soil. The fixture shall include a lockable steel lid with the welded legend “C. P. Test” in one (1) inch high letters.

11.6.10.5 Test Station Lead Wires - The test station structure and anode lead wires shall be black in color and a No. 12 AWG stranded copper wire with NFPA 70 type THW or equivalent insulation. Copper sleeve adapters shall be used when thermit welding #8, or smaller, wires to structures.

Reference electrode lead wires shall be No. 14 AWG stranded copper wire with NFPA 70 type RHH-RHW insulation.

The following color code shall be used to identify test station lead wires:

STRUCTURE	**WIRE COLOR**
Protected Structure	white
Reference Electrode	yellow
Casing	red
Unprotected Side of Insulator	green
Anode Lead Wire	black
Foreign Structure	blue

11.6.10.6 Cathodic Protection Interference and Cooperative Testing - Where more than one (1) independently cathodically protected structure is in the same area, currents flowing around one (1) structure may affect another. This is particularly true when impressed current systems are used because of their greater operating current capacity and driving voltage. To overcome this problem, two (2) lead wires shall be attached to each structure and brought to a surface test station.

Care must be taken to insulate DC powered equipment from ground or provide low resistance metallic paths for current return. Provision shall be made in the specification for interference testing by a Corrosion Engineer.

Coordination tests shall be carried out through local committees where they exist. These groups, representing all concerned area utilities and industries, coordinate testing and arbitrate solutions as

required. As a rule, the organization owning a current source is responsible for the expenditures necessary for correction of a problem that it creates.

11.6.11 Water Storage Tanks - Steel water storage tanks shall be internally coated and provided with cathodic protection. The design of the cathodic protection system must not be detrimental to the applied coatings in the wetted area of the internal surfaces when the system is properly adjusted. The design life for the cathodic protection anodes shall be a minimum of ten (10) years.

11.6.11.1 Anodes shall be installed in the tank to provide uniform current distribution to all immersed surfaces.

11.6.11.2 DC current shall be supplied by a suitable transformer - rectifier power supply located adjacent to the tank. The rectifier shall be either a constant current, constant potential or 100% manually controlled unit, at the option of a Corrosion Engineer. Manually adjusted rectifiers are the least expensive to install, operate and maintain. Manually adjusted rectifiers shall be specified unless special conditions dictate otherwise.

11.6.11.3 A permanent copper-copper sulfate reference electrode(s) shall be installed close to the wall of the tank (between anode strings) for monitoring purposes.

11.6.11.4 The anodes shall be suspended from a roof mounted fiberglass deck mounts designed so that the anodes may be inspected or replaced without entering or draining the tank.

11.7 Above Ground Storage Tanks

11.7.1 Bottom Exterior - The bottoms of above ground storage tanks set on moisture retaining pads are subject to corrosion. Tanks should be set on self-draining concrete or asphalt pads. If this is not done, external tank bottoms shall be sandblasted and coated with an approved coating system, and provisions shall be made to apply cathodic protection. All tanks not set on self-draining concrete or asphalt pads, shall have a minimum of one (1) permanent reference electrode installed beneath the center of the tank.

When tanks are to be located on properly drained pads, one (1) coat of an approved inorganic zinc coating shall be applied to the externally sandblasted surface prior to erection. The dry film coating thickness range shall be from 2.5 - 4.0 mils. Otherwise, cathodic protection shall be provided for the external tank bottom.

11.7.2 Tank Interior - The interior of all storage tanks shall be sandblasted and protected with an approved protective coating. If the tanks are equipped with floating roofs, the coating system shall have sufficient abrasion resistance to withstand movement of the roof.

11.7.3 Tank Exterior - The exterior surface of the tanks shall be coated with an approved coating.

11.8 Underground Storage Tanks - All metallic underground fuel storage tanks (UST) or fittings shall be coated and cathodically protected or installed in containment piping systems in conformance with local, state and federal regulations.

11.8.1 Ferrous metal UST's and appurtenances shall be coated with a cold applied coal tar mastic coating.

11.8.2 If an approved (holiday free) factory fiberglass cladding system of at least 100 mils thick is applied, no cathodic protection is required. The appurtenances attached thereto shall be coated with a compatible coating and cathodically protected.

11.8.3 As an alternate, fiberglass reinforced plastic tanks may be installed. Ferrous metal appurtenances attached thereto shall be coated and cathodically protected or installed in containment piping systems. Where submerged turbine pumps are employed, a polarization cell equivalent to Kirk Cell® K-5 shall be installed in the grounding circuit of the electrical power supply.

11.9 Hydraulic Elevators and Lifts - All direct buried hydraulic elevators or lifts shall be coated with either a coal tar-based coating or other approved coating. The lift shall be isolated from all electrical equipment with insulating fittings. Cathodic protection shall be applied.

11.10 Fuel Hydrant Boxes - Flush mounted steel hydrant boxes to be located below grade shall be externally coated with a coal-tar-based coating and cathodically protected. Cathodically protected piping entering and leaving the box shall be electrically isolated from the hydrant connection. All piping within the box shall be bonded together. Cathodic protection shall be provided to both the piping and fittings in contact with the soil.

11.11 Piling - Any steel in buried piles, directly exposed to the earth, shall be coated with a nominal 16 mil DFT single coat coal tar epoxy and cathodically protected if the strength of the full steel cross-section has been used in meeting structural requirements. The steel component of piles, if directly exposed to the soil, shall be bonded together by welding a reinforcing bar between all components or by provision of adequate bonding cables.

-- END DIVISION --