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(Lt Col Michael J.W. Kaminskas)
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This instruction implements AFPD 32-10, *Installations and Facilities*. It provides responsibilities and general requirements for the corrosion control program at major commands and bases. It applies to personnel involved in design, construction, acquisition, operations, and maintenance of real property assets and installed equipment at installations and facilities. It implements Environmental Protection Agency, Department of Transportation, and Occupational Safety and Health Administration regulations, and guidelines pertaining to corrosion control activities. It follows selected industry standards published by NACE International (formerly National Association of Corrosion Engineers). Paragraphs not applicable to the Air National Guard contain parenthetical phrases, usually at the end of the paragraph. Send comments and suggested improvements on AF Form 847, **Recommendation for Change of Publication**, through major commands to Headquarters Air Force Civil Engineer Support Agency, Directorate of Systems Engineering, Electrical Engineering Division, HQ AFCESA/ENE, 139 Barnes Drive, Suite 1, Tyndall AFB FL 32403-5319. AFI 21-105, *Air Force Fabrication Programs* (portion formerly AFR 400-44), explains the corrosion control program for aerospace and electronic systems.

(AFSPC) This supplement implements and extends the guidance of Air Force Instruction (AFI) 32-1054, *Corrosion Control.* The AFI is published word-for-word without editorial review. Air Force Space Command (AFSPC) supplemental material is indicated in bold face. This supplement describes AFSPC's procedures for use in conjunction with the basic AFI. It applies to HQ AFSPC, its subordinate units, and to all organizations supported by Headquarters Civil Engineering Directorate (CE), 150 Vandenberg Street, Suite 1105, Peterson AFB CO 80914-4150. It establishes additional responsibilities and requirements for the Air Force Space Command (AFSPC) Corrosion Control Program. Additionally, AFSPCI21-105, *Air Force Space Command Corrosion Program*, explains the program for preventing, detecting, and treating corrosion on aircraft, missiles, spacelift vehicles, communications-electronics equipment and Aerospace Ground Equipment

(AGE). This supplement does not apply to Air National Guard or Air Force Reserve Command units. Upon receipt of this integrated supplement discard the Air Force basic publication.

SUMMARY OF REVISIONS

This revision updates the requirements formerly in AFR 91-27 and AFR 91-40, reorganizes text, and adds a report control symbol to comply with the facility requirements and funding metric of AFPD 32-10.

(AFSPC) The revision of this publication is to meet the format standards required by Air Force, no content material has changed. Some required format changes have been made to allow for the conversion process.

1. Objectives. The primary goals of the corrosion control program are to develop and maintain dependable and long-lived structures, equipment, plants, and systems; conserve energy; reduce costs due to corrosion, scale, and microbiological fouling; and ensure compliance with Environmental Protection Agency, Department of Transportation, Occupational Safety and Health Administration, and other applicable regulations and guidance.

2. Scope. Corrosion control keeps the effects of electrochemical or chemical attack on materials by the environment to a minimum. The program includes:

- Corrosion control by design and materials selection.
- Use of cathodic protection to eliminate electrochemical reactions (corrosion).
- Use of industrial water treatment to reduce corrosion, scale-forming deposits, and biological growths in heating and cooling systems.
- Use of protective coatings to reduce atmospheric corrosion or cathodic protection current requirements.
- Analysis of logs and records for failure prediction and selection of corrective actions.
- Incorporation of corrective actions in repair and construction projects when corrosion, scale, or material deterioration occur due to materials, design, construction, operation, or the environment.

3. Responsibilities:

3.1. Headquarters Air Force Civil Engineer Support Agency. The Air Force Civil Engineer Support Agency (AFCESA) oversees the Air Force's facility corrosion control program in the Directorate of Systems Engineering, Electrical Engineering Division (HQ AFCESA/ENE). The agency must:

3.1.1. Assist The Civil Engineer, HQ USAF (HQ USAF/CE) in formulating corrosion control policy.

3.1.2. Maintain Air Force corrosion control technical publications and coordination on tri-service technical publications. Develop technical standards, criteria, and procedures with Department of Defense staff elements and other federal agencies.

3.1.3. Provide specialized field assistance and consultation to Air Staff and major commands on special corrosion control problems, including designs, construction acceptance, and failure analysis.

3.1.4. Provide corrosion literature searches and deliver any publicly available, but difficult to find, engineering document. Through agreement between HQ AFCESA and Armstrong Laboratory's Environics Directorate (AL/EQ), contact the Technical Information Center as follows for literature or documents:

Technical Information Center
AL/EQ-TIC (FL 7050)
139 Barnes Drive, Ste 2
Tyndall AFB FL 32403-5323
Defense Switching Network (DSN) 523-6285
FAX: (904) 283-6286
FAX: DSN 523-6286

3.1.5. Approve corrosion control methods and equipment not specified in Air Force publications.

3.1.6. Maintain a list of all corrosion points of contacts at the major command level to include full name, complete mailing address, DSN and commercial telephone and fax numbers, training received, and assigned corrosion duties.

3.1.7. Compile each fiscal year a summary of funded projects justified all or in part by corrosion control and a summary of leak records. Catalog and analyze these data for trends.

3.1.8. Provide HQ USAF/CEO and major commands the summary of data collected for the past fiscal year and analysis of trends. (RCS: HAF-CE(A)9437, *FY Summary and Trend Analysis of Corrosion Control Project and Failure Data*. This report is designated emergency status code D. Discontinue reporting during emergency conditions.)

3.2. Major Commands. Major command civil engineers assist bases in developing and executing corrosion control programs (including aqueous, atmospheric, and underground corrosion) to ensure compliance with Department of Defense and Air Force policy; Environmental Protection Agency, Department of Transportation, and Occupational Safety and Health Administration regulations; and local (including host country) requirements. Major command civil engineers, or designated representatives:

3.2.1. Assign the office of primary responsibility for the program. Appoint command corrosion engineers to act as the overall focal point in all corrosion control related matters. Appoint staff engineers as required to work with the command corrosion engineers as technical consultants in the three major areas of corrosion control--cathodic protection, industrial water treatment, and protective coatings.

3.2.1. (AFSPC) Corrosion control responsibilities at the Major Command are shared: HQ AFSPC/CECO is responsible for policy and guidance. HQ AFSPC CEF/CEO is responsible for execution. An individual from each office is appointed to perform their assigned duties in the Command Corrosion Control Program. The Major Command will send names of the corrosion control engineers, telephone/FAX numbers, E-mail addresses and regular mail addresses in a message of introduction to all Base Civil Engineers in the Command.

3.2.2. Provide installations with technical assistance and guidance on corrosion control. Develop a major command training policy for corrosion control to support budget requests. Past experience indicates that some type of annual contact with others involved in corrosion control main-

tains interest, allows networking on day-to-day problems, and cross feeds new approaches and solutions. This is significant as most corrosion control positions are one-deep.

3.2.2.1. (Added-AFSPC) The Command Corrosion Control Engineers will assist in obtaining needed training for corrosion control personnel within the Command. Training shall be investigated through private industry as well as government sources.

3.2.2.2. (Added-AFSPC) The Command Corrosion Control Engineers will periodically visit installations within the Command to evaluate the effectiveness of corrosion control programs, adequacy of training, and provide necessary guidance.

3.2.2.3. (Added-AFSPC) The Command Corrosion Control Engineers will ensure all installations within the Command develop, establish, and maintain an effective, comprehensive corrosion control program which includes annual base-wide surveys.

3.2.3. Regard corrosion control as a functional design requirement of all facilities exposed to the environment. Ensure data and justifications are part of each project. This applies to all phases--from planning, project definition, and programming through design and construction to final acceptance. Programming documents should include environmental and safety factors and associated costs. Ensure key corrosion control features of projects have separate design documentation, including drawings, specifications, and design analyses.

3.2.3.1. (Added-AFSPC) The Command Corrosion Control Engineers and Environmental Division (CEV) will ensure the Command Corrosion Control Program includes sound pollution prevention practices.

3.2.4. Ensure accomplishment of designs, design reviews, and construction inspection by qualified individuals according to major command policy for Military Construction Program and Operations and Maintenance projects. Past experience indicates design qualifications should include recognition by professional organizations, such as NACE International or state registration authorities, or 5 years experience in design and maintenance of the corrosion control measures under review. Consult HQ AFCESA or the Air Force Center for Environmental Excellence (HQ AFCEE) for review support when necessary.

3.2.5. Forward to HQ AFCESA/EN, by 1 December each year, the prior fiscal year's DD Forms 1391, **FY19__ Military Construction Program**, for corrosion-related funded projects, and AF Forms 1687, **Leak/Failure Data Record**, for system leaks and failures. Projects involving underground piping and tanks, on-ground tanks, and water tank interiors are of particular concern under cathodic protection. Projects involving chillers, cooling towers, boilers, boiler system components, closed systems, and distribution piping in heating and cooling systems are of interest under industrial water treatment. Protective coatings projects should emphasize high-value, steel structures and premature coating failures. (Not Applicable to the Air National Guard)

3.3. Design Agents (Air Force, Army, Navy, or Air National Guard). Design agents shall:

3.3.1. Ensure design according to publications referenced in **Attachment 1**.

- Accomplish surveys and design before construction contract advertisement or before construction in design-build contracts.
- For design (Air Force, Army, Navy, or Air National Guard) of corrosion control measures, ensure designer or design reviewer meets qualifications according to major command policy. For example, an experienced NACE International Accredited Corrosion Specialist,

NACE International Certified Cathodic Protection Specialist, or a Registered Professional Corrosion Engineer accredited or registered in cathodic protection should perform contracted cathodic protection surveys and designs.

3.3.2. Not delete corrosion control measures from any design without the specific approval of the command corrosion engineer. (Not Applicable to the Air National Guard)

3.3.3. Coordinate with the command corrosion engineer and the base corrosion control engineer during preliminary design. This coordination will ensure compatibility of design with existing corrosion control systems and maintenance of successful techniques within craftspersons capability. Installation personnel will approve the updating of systems and equipment per designer's recommendations.

3.3.4. Perform failure analysis for replacement projects that did not achieve life expectancy. Ensure complete understanding of the failure and include procedures in the specifications to prevent recurrence. This analysis shall be part of the preliminary design submittals.

3.3.5. Coordinate among design team members to ensure material selections and system designs are compatible with the corrosion control approach selected.

3.3.6. Not allow the construction contractor to continue with any work until approval of the corrosion control system shop drawings. The technical reviewer, usually the contracting officer's technical representative, shall be knowledgeable in the installation of the corrosion control systems.

3.3.7. Ensure the contractor notifies the contracting officer a minimum of 24 hours prior to installation, testing, or final acceptance of corrosion control systems.

3.3.8. Ensure the construction inspector understands the corrosion control system installation or will involve the base corrosion control engineer or craftsperson as technical advisor. This involvement includes construction surveillance during installation, testing, and final acceptance. If the construction agent cannot ensure the presence of an in-house inspector during cathodic protection work, the construction agent shall use Title II construction inspection services to obtain a full-time qualified inspector.

3.3.9. Ensure the specifications contain acceptance testing to ensure achievement of design criteria and the contractor performs this acceptance testing with installation representatives in attendance.

3.3.10. As-built drawings shall provide the location of corrosion control system equipment, testing points, sampling points, and items requiring periodic maintenance.

3.4. Designers. Designers shall:

3.4.1. Use field surveys, field tests, and experience of installation personnel in the design.

3.4.1.1. (Added-AFSPC) Designers shall take into account project siting before beginning design. Project Siting can be the most important corrosion consideration during a project's definition and design. Metallic structures and components located at low humidity bases that are away from the ocean require less maintenance than at those bases adjacent to the ocean. If a large metallic structure is mandated, a high, dry siting should be considered during the initial project definition phase.

3.4.1.2. (Added-AFSPC) Structures that must be located on ocean adjacent installations can greatly decrease corrosion maintenance costs by being located as far from the ocean as possible. Locating the structure on a hill 500 feet or more above the ocean or on the opposite side of the base from the ocean decreases but does not eliminate corrosion related material failures.

3.4.1.3. (Added-AFSPC) When neither of the above considerations is possible, extra corrosion control systems, special protective coatings, and additional care in material selection are necessary during the design process.

3.4.1.4. (Added-AFSPC) Another way of reducing salt air infiltration into electrical equipment, mechanical rooms, and items of mechanical equipment is to use sacrificial air filtration systems to remove the salt and humidity from ventilation air. The filters are much cheaper to replace than repairing or replacing the equipment they protect from corrosive atmospheres. An example of the filtration system method is the use of two-inch thick, close-ferrous metal air filters which are sprayed with an adhesive oil to capture the salt particles from the incoming air.

3.4.1.5. (Added-AFSPC) Utilization of Controlled Atmospheres. Some AFSPC assets located in extremely corrosive atmospheres are most economically protected by dehumidifying the structure with air conditioning. Past examples have been mechanical rooms, standby generator rooms, and hazardous material storage rooms where metal containers must be used. The installation commander is hereby given the authority to approve air conditioning of non-occupied buildings for corrosion control purposes on a case by case basis, dependent on mission criticality and cost effectiveness.

3.4.1.6. (Added-AFSPC) Construction Project Design. Project books, Requirements and Management Plans (RAMP), drawings, and specifications for new construction projects must include corrosion control considerations and "lessons learned" at the installation. The drawings and specifications must be reviewed and approved by the base corrosion control engineer.

3.4.2. Specify the testing necessary for the final acceptance of the corrosion control system. Target values of system operating parameters will be part of this testing to ensure the facility will function within design limits. Ensure the acceptance testing protocol includes procedures if acceptance testing differs from target values. Consult operations personnel, equipment manufacturers, and the construction contractor to determine solutions and set new equipment operating points.

3.4.3. Incorporate operability and maintainability into the overall design and the corrosion control systems. Designs will provide minimum life cycle cost over the facility life expectancy.

3.4.4. Provide detailed calculations and one-line diagrams at the preliminary design stage to show the magnitude and layout of the corrosion control system. For example, validate the use of pre-engineered tanks with factory installed cathodic protection through appropriate calculations and field tests.

3.4.5. Provide corrosion control system drawings to show location of equipment, test points, sampling points, potential cathodic protection interference, items requiring periodic maintenance, and installation details.

3.5. Civil Engineer Squadrons. Base civil engineers will:

3.5.1. Ensure appropriately qualified and trained personnel develop and execute a comprehensive corrosion control program, encompassing the three areas of corrosion control. Ensure compliance with applicable Federal, state, local, and host nation laws and regulations, particularly those related to public safety and environmental protection. The program will include applying and maintaining effective corrosion control methods in design, operations and maintenance, quality assurance, and acceptance testing.

3.5.1.1. (Added-AFSPC) Base Civil Engineers will develop and maintain an effective corrosion control program at all installations where Air Force Civil Engineering has responsibility for property, materials, supplies, and equipment. The Base Civil Engineer will appoint a single focal point for corrosion control. The name, office symbol, and telephone/FAX number will be forwarded to the MAJCOM Corrosion Control Engineers annually, by 1 November of each year.

3.5.2. Publish a squadron operating instruction for the corrosion control program. Ensure civil engineer squadron craftspersons receive annual training on the requirements of the squadron operating instruction.

3.5.2.1. (Added-AFSPC) Training Requirements. Annual training of personnel in corrosion control is both essential and required for an effective corrosion control program. The installation Base Civil Engineer ensures all personnel (including design personnel) dealing with corrosion control are adequately trained. Training should include course, conference and workshop attendance as well as on-the-job training.

3.5.2.2. (Added-AFSPC) NACE Conference. Attendance at the National Association of Corrosion Engineers (NACE) annual conference or the annual NACE/Military Tri-Services Corrosion Control Seminar can be a good source of annual training. For additional information on the NACE conferences or other corrosion control courses, contact the MAJCOM Corrosion Control Engineers.

3.5.3. Forward to the command corrosion engineer, by 1 November each year, the prior fiscal year's DD Forms 1391 for partially or totally corrosion-related funded projects, and AF Forms 1687 for all system leaks and failures. See paragraph **3.2.5.** for additional information. (RCS: HAF-CE(A)9437) (Not Applicable to the Air National Guard)

3.5.3. (AFSPC) Installations will submit all report inputs to HQ AFSPC CEF/CEO, 1520 East Willamette Avenue, Colorado Springs CO 80909-4554, in written form.

3.5.4. The base corrosion control engineer must:

- Develop and manage the base corrosion control program.
- Assist programmers in narrative and cost estimates for corrosion control line items on DD Forms 1391.
- Participate in project design and design review related to corrosion control. Sign all project drawings when corrosion control measures, operability, and maintainability are adequate.
- Provide technical advice to the construction inspector during installation, testing, and final acceptance of corrosion control systems.

- Coordinate operations and maintenance of corrosion control systems with the operations flight, including preventive maintenance scheduling. Ensure control charts for industrial water treatment detail the frequency and actions for testing and adjustment of each system.
- Review corrosion control records and take action to correct deficiencies.
- Investigate leaks from corrosion, tuberculation and scaling in heating and cooling systems, and premature failure of protective coatings. Take corrective action in each case, other than simple repair by replacement.

3.5.4.1. (Added-AFSPC) Attachment 2 (Added) is a checklist of minimum essential corrosion prevention tasks to be performed at specified intervals and lists sources of guidance for performing these tasks. In addition to the items listed in the checklist, the corrosion control program should also contain provision for cross-checking corrosion control decisions during site selection, project design, project location, material selection, construction quality control, and installation operations and maintenance.

3.5.4.2. (Added-AFSPC) Accurate as-built drawings showing the location of all cathodic protection systems must be maintained. The cathodic protection system master plan must show and describe all installed rectifiers, ground beds, and all anodes. The installation corrosion control engineer is responsible for ensuring cathodic protection maps are updated to show modifications made on the systems. The location of neighboring structures and test stations should also be indicated.

3.5.4.3. (Added-AFSPC) Protective Coatings. The installation corrosion control engineer will monitor all phases of projects to be reviewed for adequacy in protecting against corrosion. The corrosion control engineer is also responsible for ensuring all facilities are recoated or repaired to prevent corrosion and that recoating or coating repair is properly done. The corrosion engineer must ensure the paint shop maintains proper coating performance documentation on all facilities painted. Additional guidance on coating selection is contained in Attachment 4 (Added). Protective coatings on all facilities with exterior metal must be inspected annually to determine if corrosion is occurring and recoated if necessary.

4. Requirements:

4.1. Environmental. Consult AFPD 32-70, *Environmental Quality* (formerly AFRs 19-1, 19-2, 19-8, 126-1, and 126-7), and associated AFIs to understand the impact of corrosion and corrosion control activities on the environment.

4.1.1. The primary environmental impact of cathodic protection is in the prevention of petroleum, oil, and lubricants corrosion-induced leakage into the environment from underground and on-ground tanks and underground piping. Cathodic protection is already a requirement on new tank installations. The goal is to prevent all notices of violation due to corrosion. Ensure compliance with AFI 32-7044, *Storage Tank Compliance*, Title 40, Code of Federal Regulations, Part 280, and applicable state and local requirements.

4.1.2. The primary environmental concern of industrial water treatment is the proper disposal of chemically treated water. Consult AFI 32-1067, *Water Systems* (formerly AFRs 91-9 and 91-10). Also consult environmental engineering and bioenvironmental engineering prior to selecting any industrial water treatment chemical.

4.1.3. The following environmental laws apply to industrial water treatment. Consult with bioenviron-mental engineering and environmental engineering to determine methods of compliance with laws and local practices.

4.1.3.1. *Toxic Substances Control Act* authorizes the US Environmental Protection Agency to control existing and new chemical substances determined to cause unreasonable risk to the public health or environment.

4.1.3.2. *Clean Water Act* includes the *Federal Water Pollution Control Act* and amendments. This act establishes limits for the discharge of pollutants to navigable waters, regulations on specific toxic pollutants in wastewater discharges, and control of oil and hazardous substance discharges.

4.1.3.3. *Safe Drinking Water Act* provides for protection of underground sources of drinking water and establishes primary and secondary drinking water standards.

4.1.3.4. *Federal Insecticide, Fungicide, and Rodenticide Act* requires the US Environmental Protection Agency to register all pesticides.

4.1.3.5. *Resource Conservation and Recovery Act* addresses the control of solid and hazardous waste. The act defines hazardous waste and controls it by a complex manifest system designed to track a waste from its generation to final disposal.

4.1.3.5. (AFSPC) The Resource Conservation and Recovery Act also outlines requirements for cathodic protection of underground storage tanks (UST). These requirements are specifically found in CFR Part 280.31 and 280.33.

4.1.3.6. *Comprehensive Environmental Response, Compensation, and Liability Act,* also commonly referred to as *Superfund,* defines procedures for responding to existing uncontrolled hazardous waste sites, establishes the National Priorities List and the National Contingency Plan, and requires the reporting of hazardous substance releases into the air, land, and water.

4.1.3.7. *Clean Air Act* regulates air emissions from stationary and mobile sources to protect public health and welfare. State and local governments have the primary responsibility to prevent and control air pollution.

4.1.3.8. (Added-AFSPC) State and Local Requirements. States and local jurisdictions may also have corrosion control requirements for underground storage tanks and associated record keeping and reporting. They may also have requirements for air quality and VOC emission limitations more stringent than federal requirements.

4.1.4. Do not use chromates in any industrial water treatment application.

4.1.5. The environmental concerns of protective coatings center upon metal content in the dried paint and volatile organic compounds that evaporate from solvent-based paint.

4.1.5.1. Lead-containing paint has a lead content no more than 0.06 percent lead by weight (calculated as lead metal) in the total nonvolatile content of liquid paint or in the dried film of the paint already applied. Do not use lead-containing paint on any Air Force facility. Note that nonlead-containing paint must still pass a Toxicity Characteristic Leaching Potential Test or be considered hazardous waste during disposal.

4.1.5.2. The US Environmental Protection Agency restricted the use of mercury-containing fungicides in solvent-thinned, oil-based paint. Exterior water-thinned paints may contain a maximum of 0.2 percent mercury (calculated as metal) in the total weight of the paint. Clear markings indicating the mercury content must be on the container. The US Environmental Protection Agency banned the use of mercury in interior paint applications.

4.1.5.3. The US Environmental Protection Agency identified six major pollutants that may harm the public health and welfare. Ozone is one of these pollutants. Since the presence of organic materials in the air directly relates to the ozone concentration in the air, volatile organic compounds used in the drying and curing of coatings have environmental impact. Volatile organic compound limits vary by region of the country and the end-use surface coating operation.

4.2. Safety. Consult AFPD 91-2, *Safety Programs*, and AFPD 91-3, *Occupational Safety and Health*, as well as their associated AFIs, for guidance to minimize the risk of corrosion and corrosion control activities on facility and worker safety.

4.2.1. For cathodic protection, consult AFI 32-1064, *Electrical Safe Practices* (formerly AFR 91-12). The Department of Transportation regulates flammable utilities. The *Natural Gas Pipeline Safety Act of 1968* as amended and the Hazardous *Liquid Pipeline Safety Act of 1979* as amended provide the minimum criteria to ensure safe operation.

4.2.2. Many of the chemicals used to treat industrial water may be harmful to the health of the operator and other base personnel. They range from highly toxic to mildly irritating to the persons handling them. Handle water treatment and testing chemicals with care, following guidance in Occupational Safety and Health Administration directives, manufacturer's recommendations, and the material safety data sheets. Install eye wash stations and safety showers according to ground safety requirements. Consult with wing safety, bioenvironmental engineering, and environmental engineering on potential safety issues and the use of less hazardous substitutes.

4.2.2.1. A cross-connection is a physical connection between a potable water supply system and a non-potable system (such as an industrial water system) through which contaminated water can enter the potable water system. Consult AFI 32-1066, *Plumbing Systems* (formerly AFR 91-13). Permit only Class III backflow prevention devices (air gap or reduced pressure principle) to provide makeup from a potable water system to an industrial water treatment system.

4.2.2.2. Morpholine, cyclohexylamine, and similar chemicals added to protect condensate lines from corrosion make the steam and condensate unfit for consumption or other uses normally reserved for potable water. Do not use treated steam in direct contact with food or for any direct steam humidification, such as in a gymnasium steam room or humidity control for electronic equipment.

4.2.3. Most paint and protective coatings are hazardous to some degree. All, except water-thinned paints, are flammable; many are toxic; and others can irritate the skin. By following simple precautions, most paints are quite safe during application. Surface preparation also has intrinsic hazards. For example, sandblasting operations generate clouds of blasting media, paint, and substrate material. Dry sanding on lead-containing paint and on certain types of non-lead-containing paint can generate excessive amounts of airborne lead dust. The Occupational Safety and Health Administration controls the permissible exposure limit of these airborne

particulates and the personal protective equipment required. Consult wing safety and bioenvironmental engineering for specific information.

4.3. Design:

4.3.1. Design, construction, and application of cathodic protection, industrial water treatment, and protective coatings are functional requirements for almost all projects. Designs shall achieve the minimum life cycle cost for the overall facility. Base personnel must be able to operate and maintain the final facility design, including the corrosion control systems, without extensive training or equipment investment, unless this is the best approach to achieve minimum life cycle cost.

4.3.2. Corrosion resistance is not the only criterion for material selection. When selecting a material, investigate all aspects of its physical properties in the application environment, during both normal operation and typical system failure.

4.3.3. Clearly and distinctly document corrosion experience for future reference. This experience should refer back to design, material selection, selection of corrosion control technique, or decisions of no requirement for corrosion control. Document all design and selection decisions in project design analyses. Pass this information to the operations and maintenance elements to assist future decisions.

4.3.4. Revisit the design and selection decisions when a system malfunctions or leaks due to corrosion, scaling, or premature failure of the corrosion control system. This is especially important for the rare case when a designer justified no corrosion control being needed.

4.3.5. Ensure new or supplemental corrosion control systems are compatible with existing systems. The construction contractor shall not select the warranty period industrial water treatment.

4.3.6. Construct pipelines in a manner that facilitates use of in-line inspection tools.

4.3.7. Cathodic protection and coatings work together. Ensure these items are part of the design. Do not design submerged or buried coated metallic facilities without cathodic protection and do not design cathodic protection on bare metallic facilities.

4.3.8. Do not use unbonded coatings, such as loose polyethylene wraps. Use of unbonded coatings is a direct violation of Department of Transportation regulations and Air Force criteria for pipelines.

4.3.9. Provide both cathodic protection and protective coatings for buried or submerged metallic facilities, regardless of soil or water corrosivity, when the facility:

- Carries flammable product.
- Is mission critical.
- Would be expensive to maintain.
- Would waste energy or impact the environment if corroded.
- Requires corrosion control as identified by major command.

For other buried utilities, generally provide cathodic protection and protective coatings if the soil resistivity is below 10,000 ohm-centimeters. Follow the documented recommendations of a qualified corrosion engineer when the soil resistivity is above 10,000 ohm-centimeters.

4.3.10. Provide both cathodic protection and protective coatings for the following aboveground tanks based upon qualified analysis:

- All ferrous tanks in contact with the earth, unless built on an oil-filled sand pad with plastic liner underneath.
- Interiors of steel water distribution storage tanks.

4.3.11. Consider the need for lightning and fault current protection at isolating devices (dielectrically insulated unions and flanges) when designing cathodic protection systems. Consult AFI 32-1065, *Grounding Systems* (formerly AFR 91-43).

4.3.12. Installed cathodic protection systems shall provide protective potentials meeting criteria in NACE International Standard RP0169, *Control of External Corrosion on Underground or Submerged Metallic Piping Systems,* Section 6, *Criteria and Other Considerations for Cathodic Protection.* Structure-to-soil potentials are to be potential drop (current times resistance) free.

4.3.13. Special conditions sometimes exist where cathodic protection is ineffective or only partially effective. Corrosion personnel may deviate from this instruction after documenting the achievement of objectives and receiving command corrosion engineer approval.

4.3.14. Industrial water treatment designs or decisions begin with an analysis of the system makeup water. Consult bioenvironmental engineering and AFI 48-119, *Environmental Pollution Monitoring* (formerly AFRs 19-7, 161-14, and 161-44), for sampling potable water sources that feed industrial systems. Use AF Form 2752A, **Environmental Sampling Data**, for complete analyses to identify the quantity and relationship of water constituents for industrial water treatment purposes.

4.3.15. Acceptance testing of new heating and cooling systems will ensure the industrial water treatment system meets design and operation parameters. Boiler steam purity tests will determine total dissolved solids limits. Correlate the total dissolved solids level selected for boiler operation to the conductivity reading of a typical sample. The Water or Wastewater Laboratory at associated plants or Base Supply's Fuels Laboratory usually can measure total dissolved solids using American Society For Testing and Materials standard methods. Verify the selected condensate treatment meets design parameters by testing for copper, iron, and pH at near, medium, and far points from the boiler throughout the system.

4.3.16. Indicate locations to install corrosion coupon racks following American Society For Testing and Materials *Standard Test Methods for Corrosivity of Water in Absence of Heat Transfer (Weight Loss Methods*), D26888-92, Test Method B. The coupons are the best confirmation of industrial water treatment effectiveness.

4.3.17. Do not use nonchemical industrial water treatment devices on Air Force systems either regularly or on a test evaluation basis. Any testing of these devices requires HQ AFCESA/ENM approval of the test protocol and security. This includes the Management Equipment Evaluation Program.

4.3.18. Light reflective floor coatings include chemically resistant urethane for existing hangar floors and dry shake metallic floor topping applied to the top layer of freshly poured concrete for new floors. Ensure electrostatic discharge and slip resistance are part of the design. Include the daily cleaning requirements to cover equipment, supplies, and frequency as part of the maintenance instructions provided to the using agency.

4.3.19. Avoid using chemical strippers. If specified, perform effectiveness tests prior to award of any contract. This is especially necessary for removing lead-based paint from wood. Also, specify procedures to confirm neutralization of alkaline paint stripper through chemical testing. Alkaline residue left on the substrate is a recurring paint failure mechanism.

4.4. Maintenance:

4.4.1. Perform routine maintenance checks, surveys, and inspections of cathodic protection, industrial water treatment, and protective coating systems. Each installation must have the basic equipment and training to perform tests and measurements of installed corrosion control systems. Consult associated manuals and tables of allowances for the minimum required field inspection instruments.

4.4.2. Investigate when corrosion control actions do not achieve results. This information provides the basis for selecting corrective actions and ensuring future projects do not continue the same problems.

4.4.3. Select and apply methods for determining voltage drops during cathodic protection testing using sound engineering practices, such as contained in NACE International Technical Report 10A190 (see **Attachment 1**).

4.4.4. Cathodic protection situations involving stray currents and stray electrical gradients require special analysis. For additional information, see AFM 85-5, *Maintenance and Operation of Cathodic Protection Systems*, Chapter 6, *Interference Testing and Control;* and NACE International Standard RP0169, Section 9, *Control of Interference Currents.*

4.4.5. Industrial water treatment requires testing at a frequency that ensures the prevention of scale, corrosion, and biological formation in the heating and cooling systems. The time between testing depends on system integrity and operations. A mechanically sound system will require less frequent testing as less chemical leaves the system over time.

4.4.6. Develop and post, in appropriate locations, control charts for each boiler, cooling tower, and closed system showing the treatment chemicals used, the amount to add per operating parameter, the testing required, the limits to maintain in the system, what to do if the chemical levels are above or below the limits, and any other information peculiar to the system.

4.4.7. Perform periodic surveys to ensure effective industrial water treatment.

- Annually check the capacity of ion exchangers. Do not rely on a timed regeneration cycle.
- Once at the start of heating season and once at the end of heating season, test the condensate throughout the return system to identify potable water leakage into the condensate return system at heat exchangers. This identifies leaks at the earliest stages.
- When adding or deleting buildings to a steam system or significantly changing industrial water treatment chemicals, perform the design acceptance tests for the boiler total dissolved solids limit and verify the total protection of the condensate return system.

5. Recordkeeping. Corrosion control logs and reports are valuable in any failure analysis when problems arise. They provide the facts to make decisions. They also provide managers the status of the systems and the ability to make incremental improvements to achieve the expected life cycle of facilities, equipment, and piping. The goal is to solve the small problems at the operational level before they become so large that a major project is the only solution.

5.1. Cathodic protection recordkeeping, using prescribed forms as explained in AFM 85-5, includes the following:

- Initial close interval, anode bed, and annual corrosion surveys of installed impressed current and sacrificial systems. Use AF Form 491, **Cathodic Protection Operating Log for Impressed Current Systems**; AF Form 1686, **Cathodic Protection Operating Log for Sacrificial Anode System**; and AF Form 1688, **Annual Cathodic Protection Performance Survey**, to record these tests.
- Impressed current system checks every 60 days. Use AF Form 491 to record these checks.
- Initial and annual water tank calibrations of installed systems. Use AF Form 1689, **Water Tank Calibration**, to record these tests.
- Annual update of the Cathodic Protection Annual Performance Booklet and sent to major command. (Not Applicable to the Air National Guard)
- Leak investigation using AF Form 1687. Use the information captured on AF Forms 1687 to provide justification for system repair or replacement, for installation of corrosion control measures, and for the project narrative on DD Forms 1391. Consult AFM 91-6, *Maintenance and Operation of Gas Systems* (TM 5-654, MO-220); AFR 91-26, *Maintenance and Operation of Water Supply, Treatment, and Distribution Systems* (TM 5-660, MO-210); and MIL HDBK 1022, *Petroleum Fuel Facilities*, for leak detection and survey requirements on these systems.

5.1.1. (Added-AFSPC) General. A successful corrosion control program is highly dependent on proper implementation of required corrosion control measures. Records must be maintained by shops to determine requirements and ensure they are being met.

5.1.2. (Added-AFSPC) Personnel Files. A current roster of personnel dealing in corrosion control must be kept by the base corrosion control engineer. Individual's training status and training program attendance should also be on file.

5.1.3. (Added-AFSPC) Equipment File. Corrosion control monitoring equipment, with operational status, should be listed along with the following information:

5.1.3.1. (AFSPC) Manufacturer's data on installed equipment. This will include the dates when the equipment, cathodic protection or corrosion control material was used or installed. Special attention should be paid to the shelf life of material used in corrosion control.

5.1.3.2. (AFSPC) Lists of repair parts.

5.1.3.3. (AFSPC) Names and addresses of replacement parts sources.

5.1.3.4. (AFSPC) Repair, operating, and maintenance instructions.

5.1.3.5. (AFSPC) Calibration requirements and last time calibrated.

5.1.4. (Added-AFSPC) System Information. File folders should be maintained on all Real Property (RP) and Real Property Installed Equipment (RPIE) installation structures and assets subject to corrosion. The files for these facilities should include locations of updated shop and as-built drawings, cathodic protection program records, corrosion failure reports, and annual visual inspection reports. The list of facilities subject to corrosion should include, but not be limited to the following:

5.1.4.1. (AFSPC) Water tanks.

5.1.4.2. (AFSPC) Steel towers.

5.1.4.3. (AFSPC) Underground pipe systems.

5.1.4.4. (AFSPC) Fences and security control structures.

5.1.4.5. (AFSPC) Buildings and real property equipment.

5.1.4.6. (AFSPC) Harbor and dock facilities.

5.1.4.7. (AFSPC) Hazardous material storage facilities.

5.1.4.8. (AFSPC) Water treatment plants (potable, industrial, and wastewater).

5.1.4.9. (AFSPC) Fuel storage facilities.

5.1.4.10. (AFSPC) Bridges, signs, and other road and railroad facilities.

5.1.4.11. (AFSPC) Communication towers.

5.1.4.12. (AFSPC) Underground storage tanks.

5.1.5. (Added-AFSPC) Cathodic Protection Records. Cathodic protection program record requirements are detailed in AFMAN85-5, Chapters 8 and 9.

5.1.5.1. (AFSPC) Underground storage tank (UST) system owners and operators must maintain records IAW 40 CFR parts 280.31 through parts 280.34.

5.1.6. (Added-AFSPC) Cathodic Protection Annual Performance Booklet. Basic requirements for the Cathodic Protection Annual Performance Booklet are described in AFMAN85-5, Chapter 8, paragraph 6. The review copy of the booklet will be sent annually to the Command Corrosion Control Engineer in CEF/CEO. It may be soft cover and staple bound.

5.1.7. (Added-AFSPC) Failure Records. Records of corrosion damage and facility failures must be maintained as described below:

5.1.7.1. (AFSPC) For liquid containers and pipe lines, AF Form 1687, Leak/Failure Data Record, must be completed and placed in the facility jacket folder after each failure investigation. One copy must also be included in the "Cathodic Protection Annual Performance Booklet". The location of the leak or failure should be indicated on a base layout map. Corrective maintenance, repair, and applied corrosion control measures with costs should also be recorded and placed in the facility folder.

5.1.7.2. (AFSPC) For building and structural corrosion failures, the following information should be completed and placed in a facility folder:

5.1.7.2.1. (AFSPC) A short description of the failure.

5.1.7.2.2. (AFSPC) The date the failure was first observed.

5.1.7.2.3. (AFSPC) The method and cost of repair.

5.1.7.2.4. (AFSPC) The cause of the corrosion failure, such as dissimilar metals, corrosive atmosphere, protective coating failure, or other.

5.1.7.2.5. (AFSPC) Photos of the failure and repair. Annotate date taken and facility number.

5.1.7.3. (AFSPC) A copy of the above failure information items will also be recorded in the "Cathodic Protection Annual Performance Booklet".

5.1.8. (Added-AFSPC) A cathodic protection performance survey must be conducted annually for each facility by the base corrosion control engineer, the cathodic protection technician or by contract. Systems not performing at required protection levels must be corrected. Enter operational data and test results in appropriate logs and on AF Form 1688, Annual Cathodic Protection Performance Survey.

5.2. Industrial water treatment records should reflect the minimum entries needed to effectively manage the control of the industrial water treatment program and indicate the need for additional testing. A future publication will update treatment, testing and reporting procedures previously contained in rescinded AFP 91-41, **Industrial Water Treatment Procedures**. The reverse of prescribed forms explains their use. Associated recordkeeping includes the following:

- Accomplish industrial water treatment operating logs based upon one log for each individually treated system (each boiler, each cooling tower bank, and each closed system).
- Use AF Form 1457, **Water Treatment Operating Log for Cooling Tower Systems**, as a minimum.
- Use AF Form 1459, **Water Treatment Operating Log for Steam and Hot Water Boilers**, as a minimum.
- Keep other industrial water system records on modifications of these forms or a log developed locally for the specific tests required.
- Keep the maintenance and history of industrial water treatment, other than that contained in the logs, in a historical record for each system. This book should contain a record (including dates) of occurrences of corrosion and scale, major maintenance and surveys performed on the system, replacements of piping and equipment, accidents, outages, changes in methods of operation and treatment used, and other pertinent data to assist troubleshooting and provide facts for management decisions on process improvement.

5.2.1. (Added-AFSPC) Distribution maps should be maintained for all potable and waste water systems by the base Water and Wastewater shops. The water and waste water shops should perform raw water analysis and record complete data on water sources, consumption and potable water/waste water treatment according to AFR91-26 and AFMAN91-32.

5.2.2. (Added-AFSPC) Boiler water and cooling water treatment records must be maintained by the base Heating, Ventilating and Air Conditioning (HVAC) shop. Data is required on internal treatment, external treatment, and make-up water as a percentage of boiler output. Cooling towers must be checked IAW AFP91-35 for corrosion, algae, and scale build up. The cycles of concentration will be calculated and maintained according to survey recommendations. The base corrosion engineer must ensure the necessary corrosion tests and system examinations are performed according to Attachment 2. The base corrosion control engineer is also responsible for making sure treatment equipment is adequate and working.

5.2.3. (Added-AFSPC) Corrosion Failures. All leaks and corrosion failures must be investigated by the installation corrosion control engineer and cathodic protection technician. The cause of the failure must be determined and corrective action taken to prevent recurrence. Complete leak and failure data should be recorded on AF Form 1687, Leak/Failure Data Record. Installation layout maps should be used to record each location where an underground leak has occurred. The base corrosion control engineer can then analyze the data for patterns which indicate major problems.

5.3. (Not Applicable to the Air National Guard) Maintain records following AFM 85-3, *Paints and Protective Coatings*, Chapter 2 and Appendix B. Perform evaluations using these records after any paint failure and before any protective coatings contract. These records replace undocumented hearsay experience and allow fact-based decisions with costs and verified life expectancies of completed work to determine the following:

- Effectiveness of a particular paint system on different surfaces or in varying environments.
- Comparison of different paint systems under similar conditions.
- Comparison of different equipment for surface preparation or application.
- Frequency of spot painting and repainting.

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The Civil Engineer

Attachment 1

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AMERICAN SOCIETY FOR TESTING AND MATERIALS

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Attachment 2 (ADDED-AFSPC)

CORROSION CONTROL PROGRAM CHECKLIST

Table A2.1. Checklist.

ITEM	AF FORM	GUIDANCE	FREQUENCY
CATHODIC PROTECTION			
Annual Cathodic Protection Performance Survey	1688	AFMAN85-5, Chap 9	Annually
Select check points for monthly system readings	491	AFMAN85-5, Atchs 2, 18	Annually
Determine required rectifier currents.		AFMAN85-5, para 9-3	Annually
Check dielectric insulation	1688	AFMAN85-5, para 9-5	Annually
Physically inspect anodes in water tanks and measure structure to water potentials	1689	AFMAN85-5, para 9-14	Annually
Update Cathodic Protection Program Record		AFMAN85-5, Atch 18	Annually (Note 1)
Updaate Corrosion Protection Performance Booklet and submit to major command		AFMAN85-5, Atch 17	Annually
Initiate changes and improvements where needed through Maintenance Action Sheets and Annual Work Plan	332	AFI32-1031	As Required
Measure structure to soil potentials at each building service pipe line and at points over the pipe closet to and farthest from the anodes		AFMAN85-5, Atch 18	Annually
IMPRESSED CURRENT SYSTEMS			
Measure structure to soil potential at 4 test points for each system	491	AFMAN85-5, Atch 18	Monthly

Adjust rectifier voltages to maintain required potentials at test pointspo	491	AFMAN85-5, Atch 18	Monthly
Check rectifiers for proper operation (overheating, etc.)		AFMAN85-5, para 5-3 and Atch 12	Monthly
Test rectifier voltmeters and ammeters		AFMAN85-5, Atch 18	Annually
Check current output of each anode at deep anode beds	1688	AFMAN85-5, Chap 9	Annually
Take voltage and current readings on all rectifiers	491	AFMAN85-5, para 5-3	Monthly
Measure structure to soil potential at building service lines, and at 1000 foot pipe intervals		AFMAN85-5, paras 8-7d and 9-2 Atch 18	Annually

SACRIFICIAL ANODE SYSTEMS

Measure structure to soil potential, current output, and anode to soil potential. Measurements should be taken at service risers and at points over the pipe midway between anodes	1656	AFMAN85-5, paras 4-6, 7 and Atchs 4, 5, 18	Semiannually
Measure structure to soil potential on each side of all dielectric insulators		AFMAN85-5, para 9-5	Annually

WATER TREATMENT

Water Treatment		Previously found in AFP91-41 (Rescinded)	
Boiler Water		Previously found in AFMAN85-12 (Rescinded)	
Record internal treatment Chemicals, etc	1459		Daily
Record external treatment deaerators, softeners, decarbonators	1459		Daily (Note 1)

Test make-up water, quantity and quality		Monthly
Check for leaks in steam valves, flanges, and unions in boiler plant		Daily
Test heat exchanger for leaks		Monthly
Check pressure and temperature of deaerating heater		Daily
Determine conductivity of return condensate		Daily (Note 2)
Have condensate corrosion tests performed		Monthly
Test ion exchanger output quality		Daily (Note 1)
Check mechanical rooms with hot water heat exchangers for signs of corrosion problems		Semiannual
Check all tanks		Annually
Check piping system, boiler plant		Daily

PROTECTIVE COATINGS

Protective Coatings	Previously found in AFMAN85-3 (Rescinded)	
Update painting records		As Needed
Drain (as appropriate) clean and inspect interior of water storage tanks		Annually

Inspect coatings on all facilities with exterior corrosive metals, update Corrosion Protection Performance Booklet and put in work orders		AFMAN85-5	Annually

LEAK/CORROSION FAILURE DATE

Inspect leaks and failures	1687	AFMAN85-5, para 8-6, 8-3 and Atch 6	As they occur
Update base layout map to pinpoint leaks		AFMAN85-5, para 8-6K	As leaks are found

UNDERGROUND STORATE TANKS (UST) ONLY

All UST cathodic protection systems must be tested	40 CFR, Ch 1 Part 280.31	Within 6 months of installation at at least every 3 years thereafter
UST systems with impressed current cathodic protection	40 CFR , Part 280.31	Everey 60 days to ensure proper system operation
UST repairs	40 CFR, Part 280.33	Cathodic protection system must be tested within 6 months after repair

Notes:1. Perform more often, if required.
2. Hourly for large plants.

Attachment 3 (Added-AFSPC)

MATERIAL SELECTION FOR CORROSION CONTROL

A3.1. (Added-AFSPC) Selecting non-corrosive construction materials during the design process greatly reduces maintenance costs during the life-cycle of facilities located in corrosive environments. The following is a partial list of construction components and materials recommended for maximum corrosion prevention.

A3.2. (Added-AFSPC) Beams and Columns. Consideration should be given to using hot dipped galvanized steel or painted hot dipped galvanized steel structural members. Generally, adding protective coatings to galvanized metal will extend the expected service life of the item by one and one half times the combination life of the two systems. For example: If an item's galvanized coat is expected to last 40 years and it is painted with a paint system that normally lasts 10 years, the expected service life of the duplex system would be 1.5 X 50 or 75 years.

NOTES:

1. The paint film extends the life of the galvanized coating by protecting the zinc layers while the underlying zinc coating tends to prolong the life of the paint by preventing underlying corrosion from developing. The paint coatings also act to protect the zinc coating from scratches and cuts through to the base metal.

2. See Attachment 4 (Added) for recommended paint coatings on non-galvanized structural steel in corrosive environments.

A3.3. (Added-AFSPC) Concrete. Concrete, brick, and concrete block are preferred construction materials in corrosive environments. However, in areas where seismic activity is a concern special care must be taken in design to allow the structures to withstand ground movement. Concrete rebar in corrosive environments should be galvanized and covered with at least 2.5 inches of sound, chloride-free concrete. See Attachment 4 (Added) for recommended exterior concrete coatings in salty environments.

A3.4. (Added-AFSPC) Condensers (Air Cooled). Coils for air-cooled condensers located in corrosive environments should be fabricated with copper alloy tubes and have copper alloy fins. Copper alloys 687, 706, 710, and 715 are preferred for condenser tubing and fins in salt air environments. Aluminum fins with an epoxy phenolic coating are acceptable. Intake system cooling air should be suitably filtered. See International Service Bulletin 68-8, "Sacrificial Condenser Filters", Carrier Air Conditioning Company, Syracuse, New York, May 1968, for a recommended filter method. Consider the use of plastic or fiberglass fans for condensers and air handlers, where large quantities of outside makeup air are involved.

A3.5. (Added-AFSPC) Doors and Frames. Shop painted galvanized steel or fiberglass doors and frames should be used in corrosive environments. The hardware should be Type 304 stainless steel.

A3.6. (Added-AFSPC) Electric Conduit. Stainless steel or anodized aluminum alloys may be used for electrical conduit in above ground applications. Ultraviolet resistant fiberglass may also be specified.

A3.7. (Added-AFSPC) Exterior Electrical Boxes. Electrical boxes and other enclosures should be placed within the facilities they service for both aesthetic and anti-corrosion purposes. When elec-

trical boxes and enclosures must be placed at exterior locations in corrosive environments, they should be fabricated from fiberglass which has a proven resistance to ultraviolet light degradation. Conduits associated with these enclosures should also be specified to be ultraviolet light-resistant non-metallic. Alternatively, stainless steel or PVC coated conduits and fittings can be used above ground. Unistrut should not be used to attach boxes, conduit or other components to structural steel in corrosive environments.

A3.8. (Added-AFSPC) Fences. All posts, chain link fencing, gates, and accessories should be galvanized steel with factory applied vinyl coatings in coastal areas. See "PVC-Coated Posts and Accessories for Chain-Link Fences", Tech data Sheet No 76-16, Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, Ca. Sept. 1976 for additional data. In cases where the fence must be topped, stainless-steel, saw-tooth tape should be used.

A3.8.1. (Added-AFSPC) In less corrosive environments away from coastal areas, fence materials can be galvanized without vinyl coatings.

A3.8.2. (Added-AFSPC) In cases where security is less a factor, wood fence materials, fences from recycled materials, and concrete wall fences should be considered for both aesthetic and low maintenance purposes.

A3.9. (Added-AFSPC) Guardrails and Handrails. Guardrails, handrails, and their supports and fasteners should be fabricated from galvanized steel. Similarly, walkways and gratings should be galvanized steel or aluminized steel.

A3.10. (Added-AFSPC) Gutters and Downspouts. Gutters and downspouts should be fabricated from anodized aluminum alloy or soldered copper.

A3.11. (Added-AFSPC) Guy Wires. Aluminum-coated steel or Type 304 stainless steel wire rope should be used for the antenna support systems. If aluminum coated steel wire rope is used, it is important that the hardware in contact with the rope is also aluminum coated steel.

A3.12. (Added-AFSPC) High Voltage Electric Wire & Secondary Voltage Wire. Wire will be installed in accordance with the National Electric Code.

A3.13. (Added-AFSPC) Louvers. All louvers should be fabricated from fiberglass, anodized aluminum-alloy, or shop coated galvanized steel.

A3.14. (Added-AFSPC) Purlins. Purlins should be fabricated from hot dipped galvanized steel.

A3.15. (Added-AFSPC) Roofs:

A3.15.1. (Added-AFSPC) Avoid the use of exposed metal panels where possible in coastal areas. Built-up, single-ply, shingle, or tile roofs are preferred. Where metal panels are to be used for aesthetic purposes, the use of a thicker gage such as 18 gage in place of the standard 24-gage is needed. The use of thicker metal for roofing panels does not obviate the need for maintenance. Rather, it permits additional maintenance cycles for abrasive cleaning.

A3.15.2. (Added-AFSPC) If exposed metal roofs must be used, they should be fabricated from aluminized-steel (Type 2) that is factory coated with an oven-baked fluoropolymer enamel such as Duranar 200. The roof panels should be "standing seam" interlocking, and secured to the purlins with a concealed structural fastening system in order to preclude moisture and dirt entrapment. The "standing seams" should have a factory-applied, non-hardening sealant and should be continuously locked or crimped together by mechanical means during erection. Roof panels with

lap-type, longitudinal joints and exposed structural fasteners are not acceptable. The concealed clips or backing devices used to fasten the roof panels to the purlins or secondary support members should be fabricated from aluminized steel. Through penetration of the roofing surface by exposed fasteners should be stainless steel or aluminum-alloy screws, bolts, or rivets with weather seal washers. Roof panel cross-sections should be flat and free of cross ribbing in order to eliminate the need for closure plugs at the eaves, ridge, and roof penetrations. In humid, salty environments, use stainless steel or copper roof metal gravel stops, fascia and counterflashing.

A3.16. (Added-AFSPC) Steels:

A3.16.1. (Added-AFSPC) Uncoated carbon steels are highly susceptible to corrosion in aggressive environments and their use should be avoided to the highest degree possible in construction. Various coating systems can be used to extend the life of carbon steels but it should be remembered that all coatings contain holidays and imperfections. As a result, recoating and general maintenance must be accomplished at regular intervals to prevent coating failure and the start of corrosion (see Attachment 4 (Added).

A3.16.2. (Added-AFSPC) Naturally weathering steels such as ASTM A588 steels should not be considered for structural applications in coastal areas.

A3.16.3. (Added-AFSPC) Aluminized steels and galvanized steels should be used in applications where strength, toughness, high melting point, and low cost are factors.

A3.17. (Added-AFSPC) Ventilators. Ventilators and associated components should be fabricated from an appropriate anodized aluminum alloy, aluminized steel, galvanized steel, or fiberglass.

A3.18. (Added-AFSPC) Wall Panels. Steel wall panels are not acceptable except in very high and dry climates. Aluminized steel is not preferred. Consider fiberglass, brick, concrete, concrete block, stucco, and other non-corrosive materials.

A3.19. (Added-AFSPC) Weldments. Weldments in corrosive environments should be low-carbon grades of austenitic stainless steel (Types 316L and 304L) and appropriate filler metals.

A3.20. (Added-AFSPC) Windows. Windows and associated components should be fabricated from 6060 aluminum alloy. Where aluminum-alloy or aluminized steel windows are in direct contact with mortar or concrete which could become wet, the contacting surfaces, of the aluminum or aluminized steel should be coated with a factory-applied, clear methacrylate lacquer in order to prevent aluminum corrosion by the alkaline environment.

A3.21. (Added-AFSPC) Wire Rope. Aluminized steel wire rope or type 304 stainless steel wire rope should be used.

A3.22. (Added-AFSPC) Plastics. Plastics may be used, if technically and economically feasible, with the approval of the local corrosion control engineer.

Attachment 4 (Added-AFSPC)

PROTECTIVE COATINGS SELECTION FOR CORROSIVE ENVIRONMENTS

A4.1. (Added-AFSPC) General. Coating technology is in a period of enormous change due to environmental requirements affecting both preparation and painting. The regulations impact both paint application and the disposal of waste materials developed during surface preparation and the painting process. To comply with these regulations in a cost effective and professional manner, a fully trained manager, knowledgeable in all aspects of corrosion control may be required. For larger installations, an alternative method is to appoint one engineer to manage the protective coating program, one engineer to manage the cathodic protection program, and a third engineer to manage the water treatment program. All personnel must receive annual training to maintain currency on rapidly changing environmental and technical requirements as required by AFI32-1054.

A4.1.1. (Added-AFSPC) Surface Preparation. Surfaces should be painted as soon as practicable after abrasive blasting and in any case before exposure to rain, fog, or the appearance of rust bloom. Additionally, consideration should be given to the use of pressure water cleaning at a minimum 400 psi before abrasive blasting of ferrous surfaces in exterior coastal areas. Pressure water cleaning before painting reduces or eliminates soluble salt contamination prior to painting and greatly improves coating performance. Dry abrasive blasting alone will not remove salt contaminants. A test kit should be used to test for soluble salt contamination prior to painting in coastal areas.

A4.1.2. (Added-AFSPC) Painting Cycles and Paint Selection. The objective in facility management is not necessarily to maintain a painting cycle of 3 to 5 years. It is to properly protect that facility over its life at the lowest life-cycle cost. Since surface preparation and painting are labor-cost intensive, the least expensive paint system for long time frames is most often a high performance coating with a long service life. The coatings recommended herein are of that nature where possible.

A4.2. (Added-AFSPC) Recommendations. Protective coating recommendations for various surfaces of items of equipment and facilities at AF Space Command installations are as follows.

A4.2.1. (Added-AFSPC) Concrete and Masonry Surfaces, Exterior. Integral colored concrete masonry units are preferred over exterior concrete painting. If painting must be done, coat with a "breathing-type" coating such as poly-vinyl acetate latex. Alternatively, apply two coats of latex TT-P-1510 for semigloss or TT-P-19 for flat. Water blast cleaning before painting is recommended.

A4.2.2. (Added-AFSPC) Exposed Concrete and Masonry Surfaces, Interior. Coat with impermeable coating to serve as vapor barrier.

A4.2.3. (Added-AFSPC) Exposed Structural Steel. Two coats of aliphatic urethane over one coat of zinc rich primer (use an epoxy mid coat between the primer and first urethane coat) are recommended for exposed structural steel in areas near cooling towers and sewage treatment plants where chemicals are injected into the water. Encased shop painting may be required in cases where VOC limits prohibit the use of aliphatic urethane or zinc primer in exterior applications. KSC-STD-C-0001; Protective Coating of Carbon Steel, Stainless Steel, and Aluminum on Launch Structures and Ground Support Equipment; criteria may be used where VOC limits permit.

A4.2.4. (Added-AFSPC) Steel Structure Spot Recoating. Mechanically clean rusted areas (SSPC SP-2,3), apply one coat of alkyd TT-P-664 at 1.5 Mils dft and 1 coat each of Mil-P-28577 and 28578 each at 1 Mil Dry Film Thickness (DFT). The KSC-STD-C-0001 above also applies.

A4.2.5. (Added-AFSPC) Tank Exteriors and Other Associated Steel Surfaces. After abrasive blasting to an SSPC-SP10 (Near White Blast) finish, recoat with one coat of DOD-P-24441 Formula 150, one coat of DOD-P-24441 Formula 151, and one coat of MIL-C-85285. Film thickness shall be as per manufacturers recommendations. KSC-STD-C-0001 also applies.

A4.2.6. (Added-AFSPC) Tank Interiors, Potable Water. Reline tank interiors by abrasive blasting to Steel Structures Painting Council Surface Preparation 10 (near White Blast) and application of one coat of DOD-P-24441 Formula 150 primer, one coat of DOD-P-24441 Formula 156, and one coat DOD-P-24441 Formula 152. Film thickness shall be as per manufacturers recommendations.

NOTE:

These products are approved for use in potable water tanks and are available in VOC conforming formulations.

A4.2.7. (Added-AFSPC) Wood Surfaces. Sand and paint with one coat of latex paint (TT-P-001984) and two topcoats of latex paint (TT-P-1510 for semigloss and TT-P-19 for flat).

A4.2.8. (Added-AFSPC) Lead, Chromium, and Mercury Paints. Do not use paints containing lead, chromium pigments, or mercurial biocides.

A4.2.9. (Added-AFSPC) AFI32-7080, Pollution Prevention Program, paragraph 3.5. Affirmative Procurement, promotes the purchase of recycled-content products. Currently, latex paint is on the EPA list of proposed affirmative procurement products. GSA has NSNs for recycled latex paint that meets the same specifications as virgin paint and they are to be used as per AFI32-7080. The NSNs for recycled paint can be found in GSA's "Environmental Products Guide" and DLA's "Environmentally Preferred Product Catalog." Locally developed statements of work are to require the use of recycled paint as per AFI32-7080.