DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, DC 20332-5000

REPLY TO
ATTN OF: LEEE

SUBJECT: Engineering Technical Letter (ETL) 88-4:
Reliability and Maintainability (R&M) Design Checklist

TO:	ALMAJCOM/DEE/DEM/DEP	AFRCE-ER	HQ USAFA/DEMA	AFRCE-WR
	HQ AFCC/DEE/DEM	AFRCE-SAC	ANGSC/DEE	AFRCE/BMS
	HQ AFRES/DE	AAFES/ENC	AFIT/DET/DEM	CEEC-ES
	NAVFAC CODE 04/04	1100 ABG/DE	HQ AFESC/DEM	AFRCE-CR

1. Purpose: This letter contains design checklists to be used in developing functional, aesthetically pleasing, reliable, and maintainable facilities and systems constructed by and for the Air Force. The generic checklist will help personnel in charge of the planning, designing, constructing, operating, and maintaining of Air Force real property.

a. This letter contains guidance that applies to all new construction and to major rehabilitation, alterations, and repair of existing facilities and systems. It applies to all facllities constructed with Military Construction Programs (MCP), Unspecified Minor Construction Program (P341), Operations and Maintenance (O&M), and Non-Appropriated Funds (NAF).

b. This ETL is authorized in accordance with AFR 8-7, Air Force Engineering Technical Letters, 9 January 1986, and is to be implemented accordingly. Waivers will be processed in accordance with the procedures established by the Model Installation Program.

c. This checklist is intended to serve as a convenient guide to be used in the review and checking of plans and specifications for construction projects. This checklist can also be utilized in the early planning stages to determine if all R&M requirements are being considered for the project. Its main usefulness is to identify and highlight the most prevalent omissions and discrepancies in facility designs.

d. A secondary feature of this checklist provides a feedback system from the field on "lessons learned." A "lesson learned" is any experience of value having spplicability in furthering the goals of the R&M facility program. Lessons may depict successes on innovative techniques, or they may depict deficiencies or problems to be avoided in future designs.

2. Effective date: This ETL is to be implemented as of the date of this letter.

3. Referenced Publications: Applicable referenced publications are as follows:

a. AFR 88-15, Criteria and Standards for Air Force Construction.

b. AFR 89-1, Design and Construction Management.

c. AFR 800-18, Air Force Reliability and Maintainability Policy.

d. Construction Technical Letter (CTL): Project Book Format.

e. AFR 8-7, Air Force Engineering Technical Letters (ETL).

4. Description/Implementation: Applicable sections of this checklist should be utilized and completed for each project and remain in the project file as a permanent record. Brief explanatory notes may be inserted by the reviewer, when appropriate. For example, when checking equipment space requirements, the manufacturer of the type of equipment used to check this item should be annotated on the checklist. Also, if special reasons exist for not complying with an item, an explanation should be inserted.

a. The generic checklist, attachment 1, is not intended to cover every situation; it is a tool to aid the planner, designer, and maintainer to focus on materials, methods, and system components to enhance Reliability and Maintainability throughout the life of each facility.

b. The submittal of "lessons learned" from the users, craftsmen, technicians, designers, construction managers, and MAJCOM staffers is highly encouraged. This provides a means for continual improvement and refinement, thereby increasing the future value and usefulness of the checklist. Attachment 2 is a sample format/tear-out sheet for submittal of "lessons learned." It may not be possible to furnish all information requested in paragraph 1a. This information, while useful, is not essential. The information requested in paragraph 2 is essential if clarification or additional information is needed. Handwritten forms and freehand sketches are acceptable.

5. The action officer for this ETL is Mr. Julian L. Ius, AFESC/DEMM, AUTOVON 523-6236.

FOR THE CHIEF OF STAFF

CHARLES A SIPPIAL, COL, USAF
Chief, Engineering Division
Directorate of Engineering & Services

3 Atch
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2. Lessons Learned Ltr
3. ETL Index

cc: OASD (A&L)C

ETL-88-

ENGINEERING AND SERVICES
RELIABILITY AND MAINTAINABILITY

DESIGN CHECKLIST

AFESC

DIRECTORATE OF OPERATIONS & MAINTENANCE
AIR FORCE ENGINEERING & SERVICES CENTER
TYNDALL AIR FORCE BASE, FLORIDA 32403

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TITLE/SUBJECT/ACTIVITY/FUNCTIONAL AREA	OPR / DATE
RELIABILITY AND MAINTAINABILITY CHECKLIST	DEMM / APR 88

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 1. SITE WORK			
A.	GENERAL - check:			
1.	Siting for interferences with existing facilities and utilities.			
2.	That adequately sized service drives and turn-arounds are provided for maintenance vehicles.			
3.	That curbs and gutters are provided on streets and parking areas to contain traffic and protect pavement edges.			
4.	Design large parking lots in conference with AFM 88-43, keeping in mind problems associated with pavement cleaning and snow removal.			
5.	That the proper type of pavement is designed for areas subiect to kerosene, gasoline, or oil spillage. Portland cement concrete should be used to minimize surface deterioration. In areas subject to acid spillage, an acid-resistant coating should be applied to PCC pavement.			
6.	That the storm drainage system is designed to minimize maintenance. Velocities in open ditches and swales are controlled in order to avoid erosion of embankments and damage in general.			
7.	That adquate erosion control methods are employed in the form of curb and gutter, inlets, flumes, sodding, rip-rap, etc., as required.			
8.	That headwalls are selected considering lateral scour, bank erosion, and undercutting of headwall.			
9.	That scour apron or other suitable protection is provided at downstream end of culverts and storm drain outlets.			
10.	That sodding is used to establish turfed areas and, where necessary, lawn sprinkler systems are provided in areas where establishment and maintenance of lawn areas are difficult to achieve by natural means.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
11.	That the overall drainage and grading design around the facility provides a readily maintainable surface and considers future site development or expansion. Ensure that all areas drain satisfactorily away from the facility.			
12.	That refuse c*llection pads with privacy screens are sized and provided with necessary access to accommodate the large pickup vehicle. Is access straight into dumpster and does it provide for safe, easy backing and turnaround, if necessary?			
13.	To see that landscaping plan precludes indiscriminate planting of trees and shrubs over water and sewage lines, under power lines, or excessively close to sidewalks, buildings, roadways, or parking lots, or selection of excessively large trees or trees which may clog sewer lines.			
14.	In arid regions, full consideration should be given to maximum use of desert landscaping, consisting of earth shaping, rock ground cover or gardens, and drought resistant planting in lieu of irrigation systems.			
15.	Does the design provide for all underground nonmetallic pipe to be marked with metallic tape buried continuously along the full length 10 to 15 inches below the surface? (The tape should have a metallic center of aluminum foil, coated on both sides with polythylene.)			
16.	If the facility is vulnerable to terrorist actions, does the siting incorporate antiterrorist features as indicated in ETL 86-10?			
17.	On gutterless roof lines, is gravel lava rock or crushed stone splash area provided in the design to prevent mud splatter on lower outside walls?			
18.	In areas where mowing will be difficult, or where shade or other conditions do not support lawn growth, is a low maintenance ground cover specified?			
19.	Where a building design includes a courtyard, is an adqeuate entry provided for maintenance equipment?			

TITLE/SUBJECT/ACTIVITY/FUNCTIONAL AREA	OPR	DATE
RELIABILITY AND MAINTAINABILITY CHECKLIST	DEMM	APR 88

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 1. SITE WORK (CONTINUED)			
20.	Are sufficient motorcycle parking slots indicated in the design and shown in the paint striping plan?			
21.	Are concrete kickstand pads provided for the motorcycle slots in asphalt parking pavements?			
22.	Is the facility sited in accordance with the Base Comprehensive Plan?			
B.	LIST ANY ADDITIONAL LOCALLY UNIQUE R&M DESIGN FEATURES TO BE CONSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 2. ARCHITECTURAL			
A.	GENERAL - check:			
1.	Minutes of all design and review conferences to ensure all comments have been considered in the design and thereby preclude later costly and disruptive changes.			
2.	That Using Agency comments have been received and considered.			
3.	That specifications and/or drawings provide for special loading conditions such as hurricane winds, etc, since they would affect anchorages, door design, window design, etc.			
4.	For prefabricated structures, the design must provide for a sturdy, well-caulked building. Windows, doors, and hardware must be of the best quality. Wall panels must have sufficient intermediate supports to limit deflection under maximum design wind loads so as not to destroy weather seals. Where wind-driven rain prevails, provide weather vestibules at main entrances.			
5.	In multistory buildings, mechanical and electrical equipment rooms should be on the ground floor, wherever possible, with doors of adequate size to accommodate the installation and removal of equipment for repair and maintenance. Grade-level boiler rooms and mechanical rooms shall normally be provided with doors to the exterior. Doors from the power rooms, generator rooms, etc, should be to the outside of the building only.			
6.	Ensure adequate space is provided in utility and mechanical rooms for the proper operation and maintenance of installed equipment. Check equipment sizes with manufacturers' catalogs. When deemed necessary, ensure mechanical specifications include maximum allowable equipment sizes.			
7.	Are stairways provided with non-slip nosing and tread?			
8.	Are chair rails considered for offices and conference rooms subject to hard use to reduce scuffs, scratches, and repainting of walls?			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
9.	In corridors, are plastic or metal corner protectors specified?			
10.	Check structural and mechanical drawings to determine that access openings are provided and that they are properly sized and located for proper servicing.			
11.	Provide facia/trim of low-maintenance metal, stucco, or other material.			
12.	Use brick, stucco - concrete, or other siding that requires low/no maintenance.			
13.	If buildings have gutters, downspouts should be connected to the storm drainage system (or provide concrete splashblocks).			
14.	Use of wood doors on the exterior should be avoided; however, where design conditions justify or require such use, specify only solid-core wood doors when canopy protection is provided.			
15.	For toilet, laundry, and shower areas over occupied spaces, does design provide for a three-ply membrane waterproofing? Are metal pans specified under shower areas located on floors other than on grade?			
16.	Is an access ladder/stairway provided in the design for servicing of roof-mounted equipment?			
17.	Are the specified floor finishes appropriate for their intended use (ceramic tile, terrazzo, carpeting, etc)? Are high-quality, low-maintenance materials specified?			
18.	Are interior wall finishes/wainscot materials durable, low maintenance type (such as a fabric wall covering vice paint)?			
19.	Exterior finishes - specify improved finishes to provide a longer cycle between recoatings.			
20.	Are thermal-pane windows in aluminum casing with baked on finishes specified for low maintenance and energy efficiency when justified by life-cycle cost?			
21.	Are exposed concrete floors to receive a hardener and sealer? Do not paint exposed concrete floors.			
22.	Consider the use of pitched roofs vice low-slope roofs, where possible.			

ALL PURPOSE CHECKLIST

TITLE/SUBJECT/ACTIVITY/FUNCTIONAL AREA	DATE
DEMM	APR 88

NO.	ITEM	NO	N/A
	Draw a horizontal line between each major paragraph.)		
	SECTION 2. ARCHITECTURAL (CONTINUED)		
23.	Are exterior doors for arctic bases heavy duty industrial type with maximum weather seal, and have vestibules been provided for all exterior entrance doors?		
24.	Are drinking fountains and fire extinguisher cabinets recessed in hallways to prevent damage?		
25.	Does the interior and exterior painting schedule conform to the approved Base Master Color Plan?		
26.	Flag poles specified to be of low-maintenance aluminum in lieu of painted steel?		
27.	Are effective expansion joints clearly detailed for roofs, floors, and walls at required intervals?		
28.	In corridors, are bumper rails or hard surface wainscoting specified in heavy traffic areas?		
29.	Does the design compliment adjacent facilities and is it in accordance with the Base Architectural Compatability plan?		
B.	LIST ANY ADDITIONAL LOCALLY UNIQUE R&M DESIGN FEATURES:		
1.			
2.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 3. INTERIOR ELECTRICAL			
A.	GENERAL - check:			
1.	Ensure lightning/transient protection is installed on: service entrances, solid state uninterruptible power supplies, isolation transformers, etc. Electronic equipment should be protected by hybrid (gas tube - transzorb or MOV - transzorb) surge protectors.			
2.	Ensure ground fault protection is on feeders if present on service entrance. NEC requires ground fault protection on grounded wye services of 150v or more to ground and 1000 amps or more. To ensure electrical coordination, ground fault protection should also be put on all feeder circuits.			
3.	Is sensitive electronic equipment installed according to Federal Information Processing Standard (FIPS) Publication 94, Guidelines on Electrical Power for ADP Installations?			
4.	Are isolation transformers grounded according to FIPS Pub 94? Shield, equipment grounding conductors, secondary neutral are to be bonded to same location on transformer case which is grounded according to NEC for separately derived sources.			
5.	Maintenance free gel-cel type batteries used in all emergency lights except fluorescent lights where NICAD is acceptable?			
6.	Correct overloads specified for motors? Overloads should be no larger than specified in the NEC.			
7.	Adequate workspace around equipment?			
8.	Electrical equipment room with dry transformers ventilated to limit temperature to 90 deg. F max?			
9.	Are grounding systems in compliance with NEC? No separate grounds for computers are permitted.			
10.	Has short circuit analysis and coordination study been performed for large or complex systems? Study should be computerized.			
11.	Is interrupting rating of breakers and fuses adequate according to findings of the short			

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*     *   circuit analysis?                                    *      *     *         *
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NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
12.	Has electrical superintendent reviewed drawings? Have his comments been considered?			
13.	Vaporproof fixtures provided in rooms containing moisture; e.g., dishwashing and potwashing rooms?			
14.	Is alternate feed to facility required to provide increased reliability? Facilities such as hospitals or mission-essential facilities may benefit greatly from dual feeders.			
15.	Is spare stub-up provided at padmounted transformers?			
16.	Circuit breakers used in lieu of fuses? Use of circuit breakers increases R&M since spare fuses do not need to be kept in storage and restoration of circuit is not dependent on fuse availability.			
17.	Has use of bus duct been considered instead of cabling for circuits of 600 amps or greater? Circuits of this ampacity require conductors greater than 500 MCM (or 500 MCM in parallel) which is very difficult for electricians to work with.			
18.	Do motor control centers have drawout breakers, where applicable? Fused disconnects should be avoided, where possible, since breakers provide greater R&M.			
19.	Does the size and application of a motor warrant use of undervoltage motor protection? History of motor failures at base should be a factor.			
20.	Does motor control center have adequate work space to ensure maintainability?			
21.	Does switchgear have drawout breakers, lifting brackets for breaker maintenance, easy accessibility for maintenance, cable trenches, emergency lighting, and adequate instrumentation?			
22.	Were neutral wires reduced per NEC? Neutral sizes should not be reduced even though NEC allows. Neutral reduction can cause problems in locations where harmonics are present such as for electronic loads.			
23.	Is power conditioning and continuation interfacing equipment (PCCIE) provided in lieu of dedicated or isolated circuits for communication-computer systems (C-CS)? Large voltage transients have occurred on isolated/dedicated circuits during transient disturbances.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 3. INTERIOR ELECTRICAL (CONTINUED)			
24.	Are explosion-proof fixtures/systems provided in areas subject to flammable vapors? Areas of significant hazards are refueler vehicle maintenance bays, paint rooms, and aircraft fuel system docks.			
25.	Is electrical acceptance testing on complex facilities specified to be accomplished according to InterNational Electrical Testing Association Standard ATS-1987? (Copies of this standard are available from InterNational Electrical Testing Association, 1718 Connecticut Avenue, N.W., Suite 310, Washington DC 20009.			
B.	LIST ANY ADDITIONAL LOCALLY UNIQUE R&M DESIGN FEATURES TO BE CONSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 4. EXTERIOR ELECTRICAL			
A.	GENERAL - check:			
1.	Has short circuit analysis and coordination study been performed? Study should be computerized, include line-to-ground faults, and coordinate largest transformer on feeder. Previous analysis may be adequate if updated.			
2.	Adequate workspace around distribution equipment (pad mounted transformer, switches, and in substations)?			
3.	Does system have sufficient looping capability? Feeders must be designed to have adequate ampacity and switching to permit backfeeding.			
4.	Adequate feeder sectionalizing capability?			
5.	Do distribution transformers have taps with external changer?			
6.	Traffic barriers around pad-mounted transformers in heavy traffic areas? This could be concrete posts painted to be highly visible.			
7.	Has electrical superintendent reviewed design drawings?			
8.	Do power transformers have the following features specified?			
	a. External tap changer.			
	b. Pressure relief valve with alarm contacts.			
	c. TR relay with alarm contacts.			
	d. Magnetic oil gage.			
	e. Oil drain and sample valve.			
	f. Filter press connections - 1 inch top and bottom.			
	g. Undercoating.			
	h. Test report.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	i. Alarm well with silencing relays, pushbutton, and indicating light in weatherproof enclosure.			
9.	Are NEMA standard voltages and frame sizes specified for motors?			
10.	Do the specifications call for compression or blast-on connections? Split bolt connections should not be specified as the quality of their installation is inconsistent.			
11.	Are standard transformers, not self-protecting transformers, specified? Maintenance of self-protecting transformers is more difficult.			
12.	Is neutral conductor not less than 1/2 the size of the phase conductors?			
13.	Are electrical items, devices, and equipment that are required to be located in areas subject to mowing or weed removal provided some type of protection such as paving at taxiway or runway lights? (Nominal areas near device, etc, to prevent weed growth and allow mowers a wider margin of safety.)			
14.	Do specifications require vacuum switches to be thoroughly tested (hipot, etc) after installation and before placing into service?			
B.	OVERHEAD DISTRIBUTION			
1.	Are corner poles as clean as possible (no switches, etc)? This ensures an easier replacement process.			
2.	Is overhead construction armless?			
3.	Adequate lightning/surge protection (MOVs on corner poles, risers, deadends, switches, transformers, etc)? Arresters must be of proper ratings and installed with short leads.			
4.	Quadraplex or triplex secondary underbuild? Is adequate ground clearance maintained?			
5.	Are the pole riser conduits steel or aluminum? PVC riser conduits deteriorate from the UV in sunlight. Aluminum corrodes when in contact with concrete. Steel conduits should be hot dipped galvanized, rigid, or intermediate. Metal riser conduits must be bonded to ground at both ends and include cable supports and seals.			

NO.	(Assign a paragraph number to each item. paragraph.)	OPR	DATE	YES	NO	N/A
	SECTION 4. EXTERIOR ELECTRICAL (CONTINUED)					
	on riser poles?					
7.	Are sectionalizing switches (OH) load-break type have stirrups? Use of stirrups prevents damage cent insulation level with outer jacket? Outer neutral from corrosion.					
2.	Are UG switches oilless with deadfronts? Vacuum + , indicators are essential to quickly locating automatically reset.					
4.	Do manholes have sufficient working space for areas), and pulling irons opposite all duct reinforcing duct entrances to reduce shearing. intrusion.					
5.	Are duct line markers used to locate duct routes Cable size should take into account any derating underground cables (IAW AFM 88-15, latest change of direction and at approximately 200 foot cables?					

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
9.	Are underground splices either prohibited or only allowed where absolutely necessary and with maintenance-free methods and materials; e.g., heat shrink and resin casting, etc?			
D.	SUBSTATIONS			
1.	Adequate bypass capability at substations so breaker can be serviced?			
2.	Are substations located away from base perimeter fences and away from heavy traffic roads? Access roads to substations able to accommodate line maintenance vehicle?			
3.	Do substations have the following features?			
	a. Two sets of multi-ratio CTs, one each for instruments and one each for relays.			
	b. Low maintenance breakers such as vacuum or SF+6, or air.			
	c. That any special maintenance tools are included as part of facility.			
	d. Two power transformers, each capable of carrying the load, should be considered for reliability and ease of maintenance.			
	e. Permanent schematics are specified to be left at the substation.			
E.	AIRFIELD LIGHTING			
1.	Is airfield lighting vault designed with 480v overhead bus duct distribution system and devices/equipment to facilitate removal and replacement of regulators, such as an overhead crane?			
2.	Was heat loading of airfield lighting vaults considered? May need to be air conditioned.			
3.	Does airfield lighting vault have adequate work space, storage area, and a latrine?			
4.	Are isolation transformers installed in cans, not direct buried? Consider installing transformers 50 from runway edge to allow maintenance work during runway use.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 4. EXTERIOR ELECTRICAL (CONTINUED)			
F.	LIST ANY ADDITONAL LOCALLY UNIQUE R&M DESIGN FEATURES TO BE CONSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A

TITLE/SUBJECT/ACTIVITY/FUNCTIONAL AREA	OPR	DATE
RELIABILITY AND MAINTAINABILITY CHECKLIST	DEMM	APR 88

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 5. EXTERIOR STRUCTURAL SYSTEMS			
A.	GENERAL - check:			
1.	Materials suitable for the environment in which they are to be used?			
2.	Components accessible for periodic inspection and/or maintenance?			
3.	Does the structural design specified provide the lowest possible maintenance effort?			
4.	Roof drains properly designed to avoid water damage to structural system?			
5.	Are expansion and control joints properly located to accommodate building movement?			
6.	Joint sealant properly selected to provide a long-term maintenance-free joint?			
7.	Crawl/attic spaces properly ventilated to prevent moisture damage?			
8.	Maintenance of structural system within local capability?			
9.	Maintenance requirements identified in the plans and/or specifications?			
10.	Is waterproof grout/mortar specified for wet area tile installation?			
11.	Are masonry and concrete surfaces specified to be sealed to prevent efflorescence and leaching?			
12.	Ventilation properly designed and functional to prevent moisture accumulation?			
13.	Vapor/moisture barriers included in the design where needed?			
14.	Doors/windows designed and sealed correctly?			
15.	Any potential settlement problems? Does design consider possible settlement?			
16.	Does the design provide for protective coatings that have been proven satisfactory for their intended use?			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
B.	LIST ANY ADDITIONAL LOCALLY UNIQUE R&M DESIGN FEATURES TO BE CONSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 6. EXTERIOR STRUCTURAL SYSTEMS			
A.	GENERAL			
1.	Review the Basis of Design, justify that all deviations from the approved criteria are warranted and will increase reliability or decrease maintenance requirements and life cycle costs.			
2.	Check technical and using agency review comments for compliance and impact on reliability and maintainability.			
3.	All openings adequately sealed (windows, doors, ports, etc)?			
4.	Interior finishes durable and require minimum maintenance?			
5.	Check closures between areas with controlled and uncontrolled environment to prevent loss of conditioned air.			
6.	Mechanical equipment room should be on the ground floor with exterior doors large enough to move equipment in or out. Rooms should also have sufficient space to permit routine maintenance without damage.			
7.	For interior mechanical equipment rooms, does design provide for sound attenuation measures (especially the doors)?			
8.	Does the design provide for support system/hangers above suspended ceilings (particularly in corridors) for future installation of ADP equipment cables, etc?			
B.	CARPENTRY:			
1.	All doors wide enough for furniture and equipment access?			
2.	Treated wood specified to be used in areas exposed to moisture or insects?			
3.	Is access to wood trusses or other areas that require periodic inspection provided in the design?			
4.	Wood and specified protective coatings compatible?			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
5.	Drainage and ventilation adequate for confined areas subject to condensation?			
C.	FLOORING:			
1.	Check selection and installation of flooring and maintenance capabilities at base level.			
2.	Is dark grout specified for ceramic tile bath floors? Consider epoxy grout in heavy use areas.			
3.	In selecting floor finishes, were moisture, soiling (abrasiveness/staining), chemicals, wheel loads, dropped objects, movable furniture, foot traffic, and traffic patterns considered?			
D.	PAINTING:			
1.	Paint application complies with AFM 85-3?			
2.	Type of paint acceptable for local environmental standards.			
E.	LlST ANY ADDITIONAL LOCALLY UNlQUE R&M DESIGN EEATURES TO BE CONSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 7. - ROOFING			
A.	GENERAL - Low-Slope Roofs (less than three inches/foot). Historically, low-slope roof systems have experienced poor performance due to a variety of factors. Some of the conditions that contribute to early failures are identified in the following checklist items.			
1.	Pitched roofs are desired in lieu of low-slope roofs. Can facility be designed with a pitched roof?			
2.	For low-slope roof designs, does design provide for a minimum slope of 1/4" per foot to ensure positive drainage of the roof surface?			
3.	Mounting of mechanical and electrical equipment on the roof should be kept to an absolute minimum. Rooftop equipment creates difficult flashing details, obstructs drainage paths, increases repairmen traffic, accelerates corrosion and equipment weathering, and negatively affects maintainability of both the roof and the equipment thereon. Is equipment properly mounted and flashed?			
4.	For cold climates, interior roof drains are preferred over perimeter drains on low-slope roofs. Are drains located at low points with consideration given to the deflected position of the structure under load?			
5.	Does the design provide for sloping the frame of the building? This is much preferred over using other methods of tapering the roof to achieve a positive slope.			
6.	Low slope roofs should not drain to cold eaves in cold regions since ice dams can develop and result in ponding. Do roofs drain to cold eaves?			
7.	Are scuppers provided, and at the proper height, as a secondary means for drainage if the primary drains become blocked? Scuppers should be designed to be approximately two to three inches above the level of the primary drains.			
8.	For buildings requiring expansion joints, are they placed at the high point with drainage directed away from them? Expansion joints must allow movement in three directions.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
9.	Does the design provide for expansion joints at the following: a. Where the deck material changes (e.g., from steel to concrete). b. Where the span of the deck changes direction. c. Between an existing building and an addition. d. Wherever the deck can move relative to an abutting wall, curb, or other building component. e. At maximum spacing of 150 to 300 feet.			
10.	Are curbs for expansion joints, area dividers, and rooftop equipment sized to permit a minimum base flashing height of eight inches? Maximum of 12 inches?			
11.	Use of tapered insulation for new construction to provide positive drainage is prohibited. Tapered insulation on reroofing of low-slope roofs is acceptable. Is tapered insulation used correctly?			
12.	Does the design provide for adding positive drainage (slope) for reroofing projects on dead-level roofs?			
13.	For low-slope roofs subjected to heavy foot traffic, are walkway pads provided to prevent roof damage?			
14.	To ensure steel deck integrity, does design provide for steel framing around all equipment openings?			
15.	Do steel decks comply with a minimum acceptable thickness of 20 gauge?			
16.	Does the design provide for insulation having a minimum compressive strength of 30 psi in order to resist traffic loads, hailstones, dropped tools, etc?			
17.	On steel decks, mechanical fastening of the first layer of insulation is required. The second layer should be hot-mopped, using bitumen adhesive. Use of cold-applied adhesives for anchoring insulation is prohibited. Is insulation properly applied?			
18.	For superior performance, is the use of double layers of insulation placed with vertically offset joints specified?			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 7. - ROOFING (CONTINUED)			
19.	Does the design provide for a minimum 18-gauge metal gravel stop or fascia strips?			
20.	Is a continuous cleat or hook strip specified for stabilizing the bottom of fascia strips?			
21.	Check location of all flashing; if at all possible, locate flashed joints above the roof water line. If impractical to follow this rule, are flashings kept out of low areas where ponding might occur?			
22.	Based on life-cycle costs, was a design incorporating the use of a protected membrane roof (PMR) system considered to enhance R&M?			
23.	Use of single-ply elastomeric membranes may be specified. Has approval for use been obtained from the MAJCOM?			
B.	GENERIC ROOFlNG SYSTEMS			
1.	Built-Up Roofing. For reroofing/replacement projects, does the design incorporate the specifications included in ETL 87-8: "Built-Up Roofing Repair/Replacement Guide Specifications?"			
2.	Standing Seam Metal Roofing System (SSMRS).			
	a. Has the designer investigated the possible use of a standing-seam metal roofing system based on life-cycle costs?			
	b. In a SSMRS, specify the use of aluminum alloy panels rather than aluminum/zinc-coated steel panels since the estimated service life is up to 75 percent greater with aluminum panels. Is the optimum material specified?			
	c. For a SSMRS, the design must provide for a minimum slope of 1/4 inch per foot under normal atmospheric conditions. Near salt water areas, minimum slope required is 1/2 inch per foot in order to enhance the life of the panel. Are the design slopes correct?			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	d. Does the design provide a minimum of two inches of vapor retarding faced insulation for noise control and condensation control under the metal panel regardless of the thermal insulation values desired?			
	e. Where roof traffic is expected for equipment maintenance, does the roof system design provide a pre-designed serviceway to keep foot traffic, tools, and equipment from damaging the roof surface?			
	f. Does the specification include the requirement that the SSMRS system shall be the design of a manufacturer who is regularly engaged in the fabrication of SSMRS for at least ten years?			
	g. Do the specifications include the requirement that the contractor has a minimum of two years experience in the installation of SSMRS?			
3.	Steep Roofing. Materials used for steep roofing include rolled asphalt, asphalt strip shingles, clay tile, concrete tile, slate tile, wood shingles, and wood shake roofing systems.			
	a. Special techniques for installation of steep roof roofing systems are adequately detailed in the National Roofing Contractors Association (NRCA) Roofing and Waterproofing Manual (Oct 86). Are these techniques used?			
	b. Does the design for the roof installation, flashing, underlayment, nailing, and ventilation details meet the basic requirements of the NRCA manual?			
	c. To enhance maintainability, selection of a long-lasting premium roofing system should be specified commensurate with the facility life cycle and architectural theme. Was the system selected on a life-cycle cost basis?			
C.	LIST ANY ADDlTIONAL LOCALLY UNIQUE R&M DESIGN FEATURES TO BE CONSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 8. WATER AND WASTEWATER			
A.	GENERAL - check:			
1.	Structural support members and hoists over large pieces of equipment to allow equipment removal for maintenance purposes.			
2.	Large equipment requiring installation or removal from the building must have an adequate building opening and associated passageway.			
3.	All equipment must have adequate space (horizontal and vertical) for itself and a work area for part or unit repair, adjustment, or removal. In some places, a maintenance platform may be necessary.			
4.	Provide adequate access with walkways and stairs to equipment and tank sidewalls for maintenance and cleaning.			
5.	Water and sewer lines located in readily accessible areas for cleaning and/or repair, not under paved roads or in heavy traffic areas when it can be avoided.			
6.	Adequate spare parts and equipment for critical repairs of the system. All pumping facilities must have spare pumps and on-line standby generator power to run all equipment.			
7.	Movable building louvers that can be closed in cold weather to protect equipment and to ensure proper comfort for O&M personnel in the performance of their duties.			
8.	Adequate piping and valves so that treatment plant components can be isolated or by-passed for operational flexibility and maintenance purposes.			
9.	That equipment and instrumentation is durable, reliable, requires minimal maintenance, and is specifically designed for water or sewage treatment system environments.			
10.	That pipes and valves are color coded and have flow direction arrows.			
11.	That sufficient sampling taps are provided throughout the system for adequate testing and process control.			

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NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
12.	Sufficient access roads and service areas are provided around outdoor equipment and for removing large internal equipment.			
13.	Thrust blocks and supports where flows change direction and at automatic valve locations.			
14.	Floor trenches around pumps to carry water spills to sumps.			
15.	Piping supported by walkways is centered or properly located and supported so that walkways will not tilt or twist under the increased loads.			
16.	Pressure gauges on the upstream and downstream side of altitude valves and on the pressure side of relief valves to allow checking and adjustment of the valve.			
17.	That all electronic or automatically controlled valves have manual override or by-pass capability where necessary for maintenance or during power outages.			
18.	Pressure gauges on the discharge side of all major pumps are specified.			
19.	Air bleed-off valves at high points in pump discharge lines to allow removal of air-locks.			
20.	That an isolation transformer is provided to separate laboratory electrical circuits from plant equipment circuits.			
21.	Complete treatment plant as-built wiring drawings, schematics, and logic circuits are provided and actual wires are labeled with identification lists at circuit breaker boxes.			
22.	Quick-disconnect electrical plugs on submerged equipment to allow rapid replacement when maintenance is required.			
23.	Adequate consideration of any potential freezing problems of piping and plant components.			
24.	That pipe penetrations in concrete tanks are provided with embedded sleeves and properly caulked.			
25.	That sufficient ground cover is provided for load protection of buried lines.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 8. WATER AND WASTEWATER (CONTINUED)			
26.	That adequate calibration equipment, special tools, and spares are provided to maintain meters and other controls.			
27.	That dry chemical feed systems and storage areas have humidity controls.			
28.	That adequate operational lighting is provided for night operations.			
29.	That provisions are made for locating nonmetallic buried pipe.			
B.	WATER SUPPLY, TREATMENT, AND DISTRIBUTION SYSTEMS			
1.	That distribution systems are looped for backfeed capabilities with adequate valving for safe, effective troubleshooting, isolation, and repair. Valve locations accessible for repair. Value box covers should be metal or have metal tags for locating with metal detector.			
2.	That well details and data are provided to allow for later servicing, repair, and redevelopment.			
3.	That potable water storage facilities are designed to preclude stagnation of the water.			
4.	That pneumatic tank systems specify cutoff and start pressures along with the associated tank volume percentages for ease of startup and servic-ing.			
5.	That raw water is used in lieu of oil to lubricate well pump bearings where practical.			
C.	SEWAGE TREATMENT AND COLLECTlON SYSTEMS			
1.	Adequate manholes and clean-outs are provided to permit maintainability. Clean-outs on pressure lines are equipped with clamp-on caps.			
2.	That manholes and tanks have ladders that are securely anchored to the wall. Ladders should be constructed of corrosion-resistant materials and SAE-T-LOCKS installed if depth is 20 feet or more so safety belts can be utilized.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
3.	That black iron is not used for ladders or handrails, etc. Ferrous metals exposed to sewage gases should be galvanized.			
4.	Paint specifications for sewage treatment plants that require intermediate and finish paint coats must be lead-free, mercury-free, fumeproof, and suitable for sewage atmosphere containing hydrogen sulfide.			
5.	That traps and separators are provided to prevent oil and grease from entering the sewage system.			
6.	For maintainability of standard sewage systems, the minimum pipe size for house connections is 6" and 8" for all other sewer lines. Sewer lines must have sufficient slope to maintain a full flow velocity of 2 ft/sec and an average flow velocity of 1.6 ft/sec.			
7.	Lift stations have:			
	a. Dual submersible pumps with automatic alternating lead pump controls with a manual override.			
	b. Adequate wastewater storage for short power outages or maintenance down time.			
	c. Adequate heat and lighting and explosion-proof switches.			
	d. Easy access for maintenance personnel and pump replacement provisions.			
	e. External switch provided for quick connection of mobile emergency generator.			
8.	Do drains from sources having possible oil or grease contamination have satisfactory separator units?			
9.	That digester tanks have ground level entry provisions and low point pump out capability.			
D.	LlST ANY ADDITIONAL LOCALLY UNlQUE R&M DESIGN FEATURES TO BE CONSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 9. INDUSTRlAL WATER TREATMENT			
A.	GENERAL - Check:			
1.	Does the system/facility require industrial water treatment (IWT)?			
2.	Was a current water analysis used in the design of the industrial water system?			
3.	Does the water treatment program specified comply with AFR 91-40 and AFP 91-41?			
4.	Is there a proper backflow prevention device specified between the potable water supply and the treated industrial water?			
5.	Is pretreatment of the water required (softener, dealkalizer, demineralizer, etc)? If so, is it included?			
6.	Is reliable, maintenance-free feed equipment specified? Continuous feed systems are preferred.			
7.	Is feed equipment easily accessible so the operator can perform operation and maintenance tasks?			
8.	Are chemical feed tanks of sufficient size for efficient operation?			
9.	Are feed pumps of the proper type and size?			
10.	Is there nearby space available for proper storage of treatment chemicals?			
11.	Are there adequate sampling points provided in the design for:			
	a. Makeup water?			
	b. System water?			
	c. Condensate?			
	d. Feedwater?			
12.	Are sample coolers specified where required?			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
13.	Is there adequate space to set up a laboratory for testing water samples?			
14.	Are corrosion test racks included in the design?			
15.	Are mechanical seal pumps rather than water lubricated seal pumps specified for closed systems?			
16.	Are system capacities provided in order to calculate amount of treatment chemicals required?			
17.	To inhibit algae growth, does the design provide a cover over the cooling tower distribution decks?			
18.	For systems subjected to freezing, are adequate freeze-protection features specified?			
19.	Is the makeup and blowdown water metered?			
B.	LIST ANY ADDlTlONAL LOCALLY UNlQUE R&M DESlGN FEATURES TO BE CONSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 10 - PLUMBING.			
A.	GENERAL - check that:			
1.	Pipe concealment spaces, furring, or chases are adequately sized.			
2.	The distance from vent to fixture trap conforms to the Uniform Plumbing Code.			
3.	An air gap or indirect waste is provided on all food service equipment as required by the Uniform Plumbing Code.			
4.	The grades of all drain lines are accurately calculated and that the invert elevations are established and indicated on the drawings.			
5.	Equipment schedules indicate the necessary units, capacities, types, sizes, special notes, etc.			
6.	Air chambers for fixtures are provided for groups of about four fixtures instead of at each faucet, control valve, or flush valve except where quick-acting valves are installed.			
7.	Electric water heaters specified to conform to Federal Specification W-H-196 have a dual type heating element and minimum size of 30 gallons.			
8.	Vacuum relief valves are specified for the cold water connection to electric water heaters. A check valve is unacceptable. Location of relief valves should be in accordance with diagrams in the Technical Manual.			
9.	In buildings taller than two stories or where the total stack height is greater than 35 feet, extra heavy soil pipe, not service weight pipe, is specified.			
10.	The drawings provide enlarged doubleline piping plans for equipment rooms or other congested areas of pipe and/or equipment.			
11.	Raw, saline, or other nonpotable water that is available could be used in secondary paths where costly treatment would not be required.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
12.	A complete legend and list of abbreviations for plumbing and HVAC are provided.			
13.	Electric heating elements in food warming tables have automatic shutof£s to prevent element failure when low water situations occur.			
14.	Shop floors slope away from equipment and hydraulic lift shafts and toward drains which are adequate in size.			
15.	Air and water are available for vehicle use external to shops and maintenance bays in order to avoid using the bays for checking water in radiators or air in tires.			
16.	When no central water softening system is available, check water analysis for hardness. If required, provide water softeners in accordance with applicable Technical Manuals.			
17.	Are backflow prevention program devices accessible to craftsman for inspection?			
18.	Are hose bibs provided on exterior walls at appropriate, strategic locations?			
19.	Are freeze-proof hose bibs specified in cold climate areas?			
20.	Is sufficient valving provided to isolate minimum system sections for repair or maintenance, by floor, wing, bay, etc?			
B.	LIST ANY ADDITIONAL LOCALLY UNIQUE R&M DESIGN FEATURES TO BE CONSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 11. FUEL FACILITY (POL)			
A.	RECEIPT - check:			
1.	Tanker off-loading			
	a. Are rigid pipe loading arms specified?			
	b. Do the drawings provide containment from all sources of fuel spill?			
	c. Are strainers located on shore?			
	d. Is the piping sloped toward shore, and are fuel stripping points provided to remove fuel for maintenance?			
2.	Pipeline			
	a. Are thermal relief valves provided with isolation valves on the relief line around all aboveground valves where piping is blocked from thermal pressure relief?			
3.	Truck/Rail			
	a. Are rigid pipe (no hose) loading arms provided at truck fill stands? Use hoses for rail off-loading only.			
4.	Filtration			
	a. Are strainers provided with easily removable covers?			
	b. Specify horizontal filter/separators with American Petroleum Institute (API) elements.			
B.	STORAGE - Check:			
1.	Underground			
	a. Provide panic hardware on doors and horizontal entry on all pump houses.			
	b. Provide three (more or less depending on the tank diameter) manways (36 inch minimum dimension) outside the pump house up to ground level. One manway will be provided with a ladder. Use a safety rail system in lieu of a			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	safety cage to allow easier access with respiratory protective gear and other safety wear. No tank openings should be in the pump house.			
	c. Pipe the high-level float valve pilot tubing back through the flange to the downstream of the high level control valve. This will prevent the free fall of fuel from the float valve pilot.			
	d. Coat all tanks.			
2.	Aboveground (vertical, reinforced concrete with steel liner called cut and cover).			
	a. The high-level float control and alarms should be accessible from the tank stairway on the exterior of the tank.			
	b. Coat all fuel storage tanks, not just aviation storage tanks.			
	c. Use only nonlubricated lift plug valves for all manual valve applications where quarter-turn shutoff is not needed.			
	d. Extend roof access stairway all the way to the ground.			
	e. Align manways with prevailing winds.			
	f. Are manway covers provided with davits (this provides for horizontal rotation of the cover without removal from the tank) for easier removal?			
C.	TRANSFER SYSTEMS			
1.	Pumping			
	a. Install flow switches with time delay on all pumps to protect the pump under no flow conditions.			
	b. All deep well turbine pumps will be provided with mechanical coupler so that the shaft seal can be removed without removing the pump motor.			
	c. Provide a dedicated on/off switch (lockable type) near each pump motor for local manual operation.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 11. FUEL FACILITY (POL) (CONTINUED)			
	d. Use only double suction split case centrifugals for aboveground suction applications.			
	e. Provide pumps larger than 15hp with a soft-start controller (solid state closed transition type preferred) to minimize the surging of fuel in the system.			
	f. Ensure deepwell turbine discharge head flange bolts attaching the pump to the tank flange are accessible and not embedded in the concrete. Elevate tank flange connection at least 4" ahove pump room floor. This will facilitate pump removal.			
	2. Piping			
	a. Provide isolation valves, as appropriate, to allow pipeline maintenance (lift plug design).			
	b. Provide thermal relief with isolation valves on the relief line around all aboveground valves where piping is blocked. This permits relief of excessive pressure when fuel temperatures increase from exposure to the elements.			
	c. Provide duplex strainers where strainers are required and pumping cannot be interrupted to clean strainers such as off-loading headers.			
	d. Use a steel sleeve on all pipe penetrations through concrete. Install positive mechanical-type seal (similar to Link Seal) on all pipe penetrations. Spacers must be installed between pipe and sleeve to ensure the pipe does not touch the sleeve. Do not use caulk.			
	e. Provide low-point stripping connection with valve on all accessible pipe and in pits where the low point is buried.			
	f. Provide isolation valves (lift plug design) every half mile or as system dictates on all piping systems.			
D.	HYDRANT SYSTEMS			
	1. Operational Tanks			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	a. Underground tanks should not normally be used. Contact the MAJCOM/DEM for assistance.			
	b. Aboveground (same as B.2.).			
2.	Pumping			
	a. Hardened (pump houses with deepwell turbine pumps (see C.1.).			
	b. Aboveground (see C.1.d.).			
3.	Filter-Separators			
	a. Use only horizontal filter separators with API elements. Provide a minimum five-foot clearance in front of vessel to facilitate filter removal and three feet on all other sides. The bottom of the door will be a maximum of five feet above the finished floor.			
	b. Use only piston-type differential pressure gauges (Gammon Technical Products) for filter separators. Do not use dial-type differential gauges.			
	c. Use weighted float feature for automatic drain valve float. This permits testing of the float.			
	d. Ensure that the pilot piping for the float control rotary disc is from a filtered source of fuel.			
	e. A11 control tube connections and small valves should be of leakproof design.			
4.	Pits			
	a. Hydrant pits will be large enough to provide at least a two-foot distance from the riser to the pit wall.			
	b. Provide a sump with water draw-off capability for all pits. Install a standpipe with a quick connect coupling at grade level.			
	c. Isolation valve pits will be provided with valve extension operators to the top of the pit. Scaffolding will be used in each pit at no more than five feet below grade.			
	d. All pits except pits in the ramp will have rolling pit covers similar to the USAFE design.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 11. FUEL FACILITY (POL) (CONTINUED)			
	e. Provide a minimum clearance of two pipe diameters or 24 inches, whichever is greater, around all flanges, valves, strainers, or similar fittings. Center all piping in valve pits smaller than four feet wide.			
	5. Controls			
	a. Automatic flow control valves will be provided with valve position indicators.			
	b. Equip all main valve body ports on automatic valves with shut-off valves to control tubing of pilot system. This will allow isolation of pilots for maintenance with less chance of a fuel spill.			
	E. DISPENSING			
	1. Truck fill stands			
	a. Underground			
	(l) Provide hydrant dead man on pressure-type fill stands.			
	(2) Use pantograph-type loading arms.			
	b. Aboveground			
	(l) Thirty-second relaxation chambers are not required at truck fill stands.			
	(2) Do not provide two-stage flow control on truck fill stands. This feature on the flow control valve sets flow rates at two different flows during initial fill and full flow. It is no longer needed.			
	(3) Pitch the receipt line to the pump to avoid loss of pump prime. Provide a flow on the pump with time delay.			
	(4) Specify a rigid pipe loading arm which uses swivel joints containing stainless steel races and easy maneuverability.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
2.	Meters			
	a. Do not include temperature compensation or recorders.			
	b. Provide inlet and outlet ports around all meters to permit calibration.			
	c. Ensure meter stands or supports so that bottom drain valve and piping are accessible.			
F.	GENERAL REQUIREMENTS			
1.	Use full-port ball valves for all applications where economy or quick closure are required. Use lift-plug valves for all manual valve applications where quarter turn shutoff is not needed. Do not use gate valves in any fuel system.			
2.	Pipe supports will be no closer than two pipe diameters from any fitting or valve.			
3.	Locate piping and valves aboveground, where possible, unless survivability requirements dictate a high level of protection.			
4.	Specify only raised-face flanges.			
5.	Provide all strainers with quick opening yoke assembly.			
6.	Provide drain piping with valve on all strainers and filter/separators.			
7.	Pipe all pressure reliefs (not thermal expansion reliefs) and air eliminators to the reclaim tank.			
8.	Provide thermal relief (with isolation valves on the relief line) around all aboveground valves where piping is blocked from thermal relief. Do not pipe to reclaim tank.			
9.	Provide the reclaim tank or drain tank from all sources of fuel drain. Provide pump out capability through filter/separator into the operating tank.			
10.	Ensure pump houses or pit design allows access with the appropriate heavy equipment for removal of large system components such as pumps or motors.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 11. FUEL FACILITY (POL) (CONTINUED)			
11.	Where heavy equipment access is not anticipated, an overhead crane of structural beam should be installed in pump houses to facilitate component removal.			
12.	Ensure all flange bolts and nuts are specified as hex head and not square head. Square head bolts tend to round off prematurely.			
13.	Electrical			
	a. Ensure voltages are nominal NEMA standard for economical acquisition and replacement of motors and controls (e.g., 460 volt motors rather than the old, pre-1965 440 or 220 volt special order items).			
	b. Install phase monitors for protection of all three-phase motors (prefer solid state starters that include phase monitors).			
	c. Pumping systems should be designed to prevent motors being installed in pits or locations subject to flooding. If this is impossible, then be sure motors are of the submersible/ explosion-proof type to preclude damage if flooded, or are designed for easy relocation.			
G.	LIST ANY ADDlTIONAL LOCALLY UNIQUE R&M DESlGN FEATURES TO BE CONSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 12. HVAC			
A.	AIR MOVEMENT AND DISTRIBUTION - check the following design requirements:			
1.	Fans and Air Handlers			
	a. That access openings are specified in fan guards for checking fan speed.			
	b. Are variable inlet vanes, variable pitch blades motor speed control, or variable discharge dampers provided for control of VAV systems? Do not rely on "fan tracking" as a method of control.			
	c. Have extended grease fittings been specified for bearings where required for access?			
	d. That access doors for cleaning coils, drain pans and fan blades are provided.			
	e. That specified equipment is in the mid range of cataloged performance to allow for adjustment during commissioning.			
	f. Inside lights provided in air handlers having 25 square feet of coil area or larger? Use exterior mounted switch with indicator light.			
	g. Ensure fan-coils are installed so as to allow full opening of all access doors.			
	h. That return fans are not used in systems having less than 1 inch w.g. return loss.			
	i. If return fans are required, ensure a minimum distance of 2 1/2 times the equivalent fan discharge duct diameter (6 times for outlet velocities 6000 fpm and higher) is provided between the fan and the return air and exhaust air dampers.			
	j. Are exhaust fans with variable inlet vanes, variable pitch blades, variable discharge dampers, or motor speed contro1 specified for all systems with economizer control strategies? Do not rely on relief vents to provide adequate exhaust capability.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	k. Install air handling units in equipment rooms where possible.			
	l. Are air handlers above suspended ceiling provided with servicing platforms, extending a minimum of thirty inches from the edge of the equipment, with a thirty-six inch high clear working space on the control side and other side where access is necessary.			
	m. That adequate clearance for servicing to include space for coil removal and filter changing is available.			
2.	Coils			
	a. Is sufficient space specified between cooling and heating coils to facilitate cleaning?			
	b. That copper tubing is specified and copper fin coils are indicated for coastal areas.			
	c. Are drainable and cleanable coils specified?			
	d. That steam distributing tube type steam coils are specified and that adequate provisions for air bleeding is provided.			
3.	Filter sections			
	a. That magnahelic pressure gauges across all medium and high efficiency filter sections are specified.			
4.	Louvers, Dampers, and Mixing Boxes			
	a. Ensure that fresh air louvers are not located adjacent to heat rejection equipment (cooling towers, etc.).			
	b. That pressure independent balancing dampers downstream of VAV terminals are specified.			
	c. That full quadrant balancing dampers for all fresh air and return air ductwork to all handling units are specified.			
	d. That duct access doors on both sides of all dampers are specified.			
	e. That specifications require the use of high efficiency dampers for all fresh air dampers and mixing boxes.			

TITLE/SUBJECT/ACTIVITY/FUNCTIONAL AREA	OPR	DATE
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NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 12. HVAC (CONTINUED)			
5.	Ductwork			
	a. That fiberglass ductwork is specified to be constructed IAW "Fibrous Glass Duct Construction Standards" of SMACNA.			
	b. That sheet metal ductwork is specified to be constructed to IAW SMACNA, "Low Pressure Duct Construction Standards or High Pressure Duct Construction Standards", as applicable.			
	c. Maximum ductwork leakage rates of 2% for round and 5% for rectangular are specified (to be tested and verified during air balance).			
	d. Is a vapor barrier material specified for all insulation intended for air conditioning ductwork?			
	e. Are access doors/panels provided at all locations which require periodic cleaning; i.e., reheat coils and VAV terminals?			
	f. That branch ducts are offset from the main trunk duct (not opposite each other) for improved "balanceability".			
	g. Are lights provided in duct chases for ease of maintenance? ...(and exterior "on/off" switch with pilot light is required).			
	h. Does design of supply and return ductwork prevent stratification? Use baffles if necessary.			
	i. Are manually operated, opposed blades or single blade, quadrant-type volume dampers specified for each branch duct take off after leaving the main duct. Splitter dampers and volume extractors are not suitable for volume control.			
	j. Double thickness or single thickness extended edge turning vanes in rectangular elbows specified?			
	k. Does design provide for manual volume dampers at branch duct connections upstream of			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	registers or diffusers? Diffuser/damper combinations are acceptable only in addition to (not in lieu of) upstream volume dampers. (Registers or diffuser dampers cannot reduce high volumes without creating high noise levels.)			
	l. That all volume dampers are located at least two diameters from a fitting and as far as possible from outlets.			
	m. That straight duct sections of at least 7 1/2 duct diameters from fan discharge, elbows, or open duct ends are shown to insure accurate traverse reading.			
	n. That duct drops to diffusers have a minimum length of two times the duct diameter to assure even distribution from the outlet.			
	o. Due to differences in pressure drop resulting in inherently unbalanced conditions, diffusers registers and/or light troffers should not be located on the same branch duct - if possible.			
6.	Terminal Devices			
	a. That pressure independent terminals are specified.			
	b. Are duct access doors provided upstream of VAV terminals and adequately sized to allow cleaning and lubrication?			
	c. That reheat coils (even in VAV applications) are not specified if avoidable.			
	d. That VAV or dual-duct terminals having distribution plates, orifices plates, or any other similar device that is susceptible to dirt entrapment are not specified.			
	e. That terminal devices are located over common use areas (where possible) to reduce interference with building occupants during maintenance activities.			
B.	PIPING			
1.	Chilled and Hot Water - check:			
	a. That thermometers and gauges at inlets and outlets of all heat exchange devices; i.e., converters, chillers, water cooled condensers, boilers, etc, are specified.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 12. HVAC (CONTINUED)			
	b. That air vents with isolation valves are specified at all high points and at heat exchangers.			
	c. To see if vapor bsrrier material is called for all chilled water piping insulation.			
	d. That chemical feeders for water treatment are specified.			
	e. That dielectric unions are specified at all connections of dissimilar metals.			
	f. That flow measurement equipment (i.g., orifice plates) are specified for all major heat exchange devices and each pump.			
2.	Steam and Condensate Return - check:			
	a. To see that condensate return lines are sloped in direction of flow.			
	b. That dielectric unions are specified at all connections of dissimilar metal.			
	c. Steam traps are located to facilitate maintenance.			
3.	Refrigeration Piping - check:			
	a. That piping is designed to provide adequate oil return.			
	b. That suction and discharge gas risers are sized for minimum gas velocities of 1000 fpm.			
	c. That horizontal suction and discharge gas lines are sized for minimum gas velocities at 500 fpm.			
	d. That p-traps are specified at the bottom of all gas risers with more than 8 feet of vectical run.			
	e. That double gas risers are specified for systems with unloading compressors.			
	f. To see that all horizontal refrigerant lines are sloped 0.5 inches per 10 feet in the direction of flow.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	g. Design provides isolation valves at inlets and outlets of all major system components and on each end of long refrigeration lines. Each separable element of the refrigeration system must have provisions for localized evacuation. Critical systems must be provided with valved bypass lines at all filter drier locations.			
4.	Cooling Coil Condensate Drain Piping - check:			
	a. That l" diameter minimum condensate drain is provided.			
	b. That the condensate drain piping is sloped a minimum of 1/4" per foot in direction of flow.			
	c. That trap provides a minimum difference in inlet to outlet elevation of 1/2 inch plus the AHU total static pressure rating.			
C.	HEAT REJECTORS (TOWERS AND CONDENSER)			
1.	General - check:			
	a. That domestic water lines with hose bibs (freeze protected where necessary) are provided adjacent to equipment for use in cleaning activities.			
	b. That extended grease fittings are specified for all internal bearings where required for access.			
	c. That 115 volt power outlet is provided adjacent to equipment.			
2.	Cooling Towers - check:			
	a. That automatically opecated chemical water treatment system is specified. Design should provide for catch basins with drains to house chemical drums.			
	b. If practical, design should provide adequately sized domestic water and drain connections to allow bypass of towers during maintenance.			
	c. That cooling towers are not located on roofs or in locations that can backfeed into building vent inlets.			
	d. That induced draft towers are specified.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 12. HVAC (CONTINUED)			
	e. That cooling towers are at adequate height above condenser water pump suction to provide the required net positive suction head.			
	f. Multiple cooling towers supplied from a common header are provided with balancing valves for each tower.			
3.	Water Cooled Condensers - check:			
	a. That ample space is allowed to inspect and clean condenser tubes.			
	b. That design provides for flanges (or unions) and isolation valves in condenser water piping located so as to allow removal of piping and headers immediately in front of tubes.			
	c. That taps, with hose bibs, are provided to allow chemical feeding for cleaning purposes.			
4.	Air Cooled Condensers - check:			
	a. That selected condensers provide a maximum condensing temperature of 20 deg. F above design ambient.			
	b. That solar effects and other site specific operating conditions are considered when specifying capacity.			
	c. That multiple fans and necessary controls are included for head pressure control.			
	d. Roof top installation is discouraged; however, if units are installed on roofs, is a level working platform extending 30 inches from the edge of the equipment on the control side and other sides where access is necessary for servicing provided?			
D.	REFRIGERANT COMPRESSION EQUIPMENT			
1.	General - check:			
	a. Are compressors located in equipment room? Do not locate on roofs.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	b. That suction discharge, and oil pressure gauges with isolation valves are permanently mounted on equipment room wall or free standing partition. (Do not mount on equipment.)			
2.	Water Cooled - check:			
	a. That compressors are located within the equipment rooms.			
3.	Air Cooled - check:			
	a. That compressors are located on concrete pads at ground level (except in desert environments).			
E.	HEAT EXCHANGERS			
1.	General - check:			
	a. That flanges or couplings and isolation valves are provided and located so as to allow removal of piping directly in front of device (above, below, and/or to the side of the device).			
	b. To see all devices are sloped to allow for proper drainage.			
	c. Does design provide adequate provisions for air bleeding?			
	d. Are taps provided with hose bibs to allow chemical feeding for cleaning purposes?			
	e. Is space provided to pull tubes or coils?			
F.	SPECIALTIES			
1.	Steam Traps - check:			
	a. That steam traps are mounted 12 to 18" below steam coil outlet to provide adequate condensate head on the trap.			
	b. That a minimum 6" dirt leg is provided before the trap inlet.			
2.	Strainers - check:			
	a. That design provides strainers upstream of all steam traps, control valves, meters and pumps.			
	b. That strainer housings are equipped with drain valves.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 12. HVAC (CONTINUED)			
	c. That critical systems provide redundant parallel strainers with isolation valves.			
3.	Meters - check:			
	a. That bypass lines and isolation valves are provided to allow removal of meters with no down time.			
4.	Valves - check:			
	a. Are ball valves in lieu of gate or butterfly valves specified?			
G.	CONTROLS			
1.	General - check:			
	a. That steel channel structural supports are provided for any actuators installed on less than 16 gage sheet metal.			
	b. That controls adhere to the provisions of Engineering Technical Letter (ETL) 83-1, Change 1.			
	c. That over current protection is specified for input and output circuits of DDC systems.			
	d. Specify dry-bulb economizer strategies in lieu of enthalpy controls.			
	e. That adequate test point connections are in stalled for determining control system pressure and voltages.			
H.	ELECTRICAL DEVICES - check:			
	That motor starter contactors rated for cyclic loading are specified (prefer solid state starters for cyclic loads).			
I.	PUMPS - check:			
	That horizontal split case pumps are specified (preferred) dependent upon application.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
J.	EQUIPMENT ROOMS			
1.	General - check:			
	a. Does design allow equipment rooms to be located along exterior walls with exterior access doors?			
	b. That sufficiently large doors or easily removeable panels are designed to allow passage of largest piece of equipment.			
	c. That floors are sloped to interior drain.			
	d. That room is provided with domestic water with hose bib and 115 volt power outlets.			
	e. That adequate wall space or full standing partitions are provided for mounting of controls.			
	f. That adequate space is allowed for wire brushing of water cooled condensers, chillers and and coils; filter removal; access to control actuators; etc.			
	g. Do all equipment item locations provide for adequate maintenance space and clearance for safety from electrical panels, switches, etc?			
K.	IDENTIFICATION			
1.	Structural - check			
	Are small labels or other unobtrusive identification tapes specified for suspended ceiling grids (t-Bar) below components; (e.g., static pressure sensors, VAV terminals and balancing dampers. Key identification nomenclature to mechanical construction drawings.			
2.	Piping - check:			
	That standard color coded labels (ANSI A 13.1) are specified for all piping at ten foot intervals. Colored pipe labels shall be printed to indicate supply, hot water return, etc., and direction of fluid flow (arrows). Color coding shall be as follows:			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A

SECTION 12. HVAC (CONTINUED)

FLUID TYPE	BACKGROUND COLOR	COLOR OR LETTERING
boiler feed water	yellow	black
chilled water	green	white
condensate return	yellow	black
condenser water	green	white
hot water supply/ret	yellow	black
make up water	green	white
steam supply	yellow	white
fuel	yellow	black

3. Valves and Steam Traps - check:

Are all valves and steam traps specified to be labeled with a numbered brass tag and connected to the valve with a brass jack chain? Tags shall be 2" round or square (minimum) with stamped black-filled lettering. In addition to numbers, tags shall be lettered to indicate fluid carried through the valve; e.g., "cw". Numbers are to be keyed to the mechanical construction drawings.

L. SPARE PARTS AND TOOLS - check:

1. Ensure that specifications provide for the contractor to furnish difficult-to-obtain and manufacturer unique spare parts upon contract completion.

2. That any special tools required to service equipment are specified to be supplied with the equipment, and that a lockable metal tool box is provided to secure tools.

M. DOCUMENTATlON

1. General - check:

Do specifications provide for documentation to be in the English language? Host country language?

2. O&M Equipment/Operating Manuals - check:

a. Requirements for O&M manuals are detailed and specified in attachment to this checklist.

b. If required, are the provisions of attachment 1 included in the contract?

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
3.	As-Built Drawings Is the contractor required to provide the 95% submittal of corrected contract drawings, indicating as-built conditions, 15 calendar days prior to scheduled O&M training? Deficiencies discovered during the training session are to be corrected by the contractor and completed drawings submitted on mylar within 15 days of completion of the training session.			
4.	Contract Drawings a. Ensure that the designer provides a separate full sheet drawing of the mechanical equipment room, showing layout of all equipment with adequate clearances for proper maintenance and repair. b. That a separate piping diagram for each pipe system showing location of all valves is provided for in the design. Valves are to be numbered on the diagram and are also listed in the valve schedule. Valve numbers are to agree with valve tags. c. That control system drawings are specified per ETL 83-1, Change 1, requirements. d. That design provides a large scale (small size) floor plan showing all zone boundaries with numerical identification of each zone.			
5.	Mechanical Room Documentation Specify that the contractor is to provide the following information with each sheet permanently mounted under clear plexiglas, in each mechanical equipment room. (1) Duct work schematic. (2) Piping schematics and valve schedules. (3) Control schematics and description of operation.			
N.	LIST ANY ADDITIONAL LOCALLY UNIQUE R&M DESIGN FEATURES TO BE CONSIDERED:			
1.				
2.				

TITLE/SUBJECT/ACTIVITY/FUNCTIONAL AREA	OPR	DATE
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NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 13 - ELECTRICAL GENERATORS			
A.	GENERAL - check:			
1.	Overhead crane for power plant or adequate overhead clearance for portable crane for removing and replacing heavy generator parts?			
2.	Adequate maintenance space around generators, switchgear, and auxiliary equipment?			
3.	Is split bus specified for redundancy and reliability?			
4.	Solid state exciter (RFI free) and voltage regulator?			
5.	Is generator compatible with SSUPS installation (harmonics, etc)? Harmonics from SSUPS may upset generator controls. Generator must be sized to handle SSUPS in rush current.			
6.	Does automatic transfer switch have bypass capability for ease of maintenance?			
7.	Has design heen reviewed by electrical superindent? Have appropriate comments been incorporated?			
8.	Are generators smaller than 750kw skid mounted?			
9.	Is grounding of prime power generators IAW IEEE Std 142, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems, and AFR 88-15?			
10.	Short circuit analysis and coordination study provided for prime power plants? Study should be computerized.			
11.	That backup generators have capability to check oil while running and refuel without shutdown. Generator should also have bypass capability with cannon plug type receptacle for quick hookup of MEPs unit in case of failure. Auto start equipment should he capable of being locked out while maintenance is being performed.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
12.	That shutdown from prime mover of backup generator is limited to low oil pressure, high temperature, and overspeed. Alarm only to status panel. Consider remote to central status location (EMCS).			
13.	Alternator has maintenance-free, sealed 50,000 hour bearing? Consider multitap leads.			
14.	Regulator for Class C generators should have auto/manual capability and should be easily accessible for maintenance/repair.			
15.	The louvers thermostatically controlled?			
16.	Are roads adeauate for easy access by service vehicles?			
17.	Prime power facilities have oil storage facilities and a storage container for used oil?			
18.	Fuel systems provide for water detection (dipstickable) and that vent and fill pipes are above the highest water level. Fuel piping should be in troughs for easy access.			
19.	That battery chargers are of float-charge type adjustable down to 0.1 amp and that batteries are the sealed, maintenance-free type.			
20.	That air start systems are redundant with diesel engines (vice gasoline). There should also be redundant air receivers.			
21.	That for multi-unit facilities, radiators should be capable of being manifolded. This allows a generator to continue running even when its radiator is out of service. Treated coolant storage should also be provided. Similar requirement for fuel systems.			
22.	Large generator units have automatic temp regulator (vice thermostat) and automatic coolant/crankcase heater with isolation valves.			
23.	That standby units which cannot tolerate reapplication of power without cycling have dropout/lockout relays.			
24.	Is exhaust located so that it will not enter intake or adjacent buildings?			
25.	Are spare parts provided? Are audible alarms provided to alert operators of abnormal conditions?			

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NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 13 - ELECTRICAL GENERATORS (CONTINUED)			
26.	Are generator switchgear breakers of the drawout type?			
27.	Is voltage generated at the distribution level when possible?			
28.	Is the control booth for larger multi-unit plant soundproofed?			
B.	LIST ANY ADDITIONAL LOCALLY UNIQUE R&M DESIGN FEATURES TO BE CONSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A

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NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 14. CORROSION PREVENTlON AND CONTROL			
A.	GENERAL - Check:			
1.	Cathodic protection/protective coatings are functional requirements for virtually all projects. Does the design include a cathodic protection/protective coating system for buried or submerged metallic piping, tanks, and related facilities?			
2.	That the following were considered in the design and selection of the corrosion prevention and control methods:			
	a. Meteorological conditions.			
	b. Soil resistivity and pH.			
	c. Chemical content of soil.			
	d. Chemical content of water.			
	e. Presence of airborne pollutants.			
3.	That all review comments have been complied with to ensure minimal impact on reliability and maintainability of the system.			
B.	CATHODIC PROTECTION - Check:			
1.	That all metallic construction members either buried or submerged in an electrolyte have been considered for possible cathodic protection.			
2.	Is the method of cathodic protection specified the most suitable for the situation encountered?			
3.	That the cathodic protection system design was based on and took into account:			
	a. Soil resistivity.			
	b. Soil chemical content.			
	c. Liquid electrolyte velocity.			
	d. Type of metal.			
	e. Design life.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	f. Source and availability of power.			
	g. The pH of the electrolyte.			
4.	When electrical isolation is required, check the following:			
	a. That the insulating flanges, unions, etc, are located as close as possible to the structure being isolated.			
	b. That the location of each insulating fitting is shown on the drawings.			
	c. That a detail sketch has been included to illustrate the components and construction of each type of insulative fitting used.			
	d. lf any buried insulating flanges are used, that details are included showing the installation of the flange field test stations and connections with the test stations.			
	e. That the installation of insulating fittings on all auxiliary connections to the electrically isolated structure is held to a minimum.			
	f. That the installation of metal jacketing applied over thermal insulation on piping does not short out insulating flanges or fittings.			
5.	Where underground metallic pipe is partially encased in concrete, check the following:			
	a. That adequate protection is provided where the pipe emerges from the encasement.			
	b. That the pipe is properly coated and cathodically protected.			
6.	Does the design identify existing cathodic protection systems in the vicinity of the construction as to location, type, and level of protection?			
7.	That the system is capable of withstanding high voltage power surges in areas with overhead power lines.			
8.	For sacrificial anode systems, check the following:			
	a. That the locations of all anodes are shown.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 14. CORROSION PREVENTlON AND CONTROL (CONTINUED)			
	b. That typical anode installations are detailed, including spacing from the pipe, depth of burial and connection of anode to the pipe.			
	c. That wire sizes and connection methods are indicated on each installation detail.			
9.	For impressed current systems, check the following:			
	a. That the locations of all impressed current anodes are shown.			
	b. That there are sufficient anodes to conduct the estimated protective current required.			
	c. That the locations of all rectifiers, terminal boxes, junction boxes, etc, are shown.			
	d. That the drawings indicate the route of the cable associated with the system.			
	e. That details show all installation details.			
	f. That wire sizes and termination methods are indicated on the drawings.			
	g. That the wiring diagram for each rectifier includes the AC power terminals, the circuit number for the AC power leads, the number and size of conductors connected to rectified output terminals, and a description of where each lead from the rectifier terminates.			
10.	For proper system maintainability, check the following:			
	a. That adequate test stations are provided.			
	b. That the test stations are located on the drawings.			
	c. That the test station installations are adequately detailed.			
	d. That test procedures sufficient to assure that the system will provide an acceptable level of protection under all anticipated operating conditions are specified.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
11.	Verify that the CP design was performed by a corrosion specialist accredited by the National Association of Corrosion Engineers (NACE).			
C.	MATERIALS - Check:			
1.	That plastics exposed to direct sunlight are specified as W resistant.			
2.	That corrosion resistance was a factor considered in the specification of metals.			
3.	That components (of valves, for example) will not exhibit galvanic action. (This may require nonstandard nuts, handwheels, levers, etc).			
4.	That materials used for piping accessories such as thermowells, pressure taps, bushings for flow switches, etc, have heen carefully considered. Early installation may be useful where internal coatings are to be applied.			
D.	COATING SELECTION - Check:			
1.	That all shop applied coatings are appropriate for the corrosive conditions they will encounter.			
2.	That all shop prime coatings are compatible with the field applied top-coatings they will receive.			
3.	That the proper surface preparation is specified for all field applied coatings.			
4.	That the appropriate application and curing methods are specified for all field applied coatings.			
5.	That all specified field applied coatings can be properly applied and cured in the environmental conditions anticipated.			
6.	That procedures are specified to assure the proper coverage and thickness of field applied coatings.			
7.	That the selection of each coating is based on a thorough analysis of the surfaces to be coated and the environmental conditions to which it will be subjected.			
E.	LIST ANY ADDITIONAL LOCALLY UNIQUE R&M DESIGN FEATURES TO BE CONSIDERED:			
1.				
2.				

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NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 15. PAVEMENTS			
A.	CRITERIA -- Check:			
1.	Was the scope of work coordinated with flight operations regarding types of aircraft and type of operations proposed for the facility?			
2.	Does the pavement type selected meet the requirements of AFR 88-15, Section E?			
3.	For airfield pavements, does the design meet the criteria as specified in Chapter 3 of AFM 86-2 and Chapter 1 of AFM 88-6?			
4.	Airfield thickness design, materials, and compaction requirements specified IAW the requirements of AFM 88-6, Chapters 2, 3, and 4? Was the Computer Aided Design Program (CADP) used to establish design parameters?			
5.	Are the airfield markings fully shown in the design drawings and comply with AFR 88-16?			
6.	Are roads designed IAW the criteria included in AFM 88-7, Chapters 1, 3 and 5?			
B.	GENERAL - Check:			
1.	Was computer program or applicable design curve used for thickness design? Should have printout showing inputs and thickness, etc, or curve attached.			
2.	Were standard specifications from the WANG design program used to develop project specifications?			
3.	Does the contract provide for full-time inspection on large projects?			
4.	Were the Air Force-developed standard design details incorporated into the design? Any deviations?			
5.	Ensure current project data is included in the Pavement Improvement Plan (PIP). (Applicable to M&R projects only.)			
6.	Is scope of project sufficient to ensure critical facilities (such as runways) will not require more project work within 3 to 5 years?			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	RIGID PAVEMENTS:			
1.	Check that design provides for joints to be spaced not greater than twenty feet.			
2.	Joint width should be a minimum of 1/2 inch regardless of joint seal type; i.e., preformed or field poured. Joint widths less than 1/2 inch have not performed satisfactorily.			
3.	Does design provide for centerline joints on runway and taxiways? Crowning of the centerline slab should be avoided since uncontrolled cracking occurs.			
4.	Are new joints and resealing of joints and cracks designed to meet the requirements of AFM 88- 6, Chapter 7?			
5.	On joint resealing projects, design should provide for the complete removal of the old joint seal material.			
6.	Neoprene compression seals are initially more expensive than field-poured sealants but have a longer performance life. The MAJCOMs will specify the type sealer to be used on new, reconstruction, or reseal projects based on life cycle costs and operational considerations. Disagreements between user and design agency with regard to design options will be resolved by HQ AFESC/DEMP.			
7.	Metal joint inserts are not to be used on Air Force pavements.			
8.	Specifications must provide for testing of joint sealants by Air Force-approved laboratory to ensure they meet applicable federal or ASTM specifications.			
9.	Liquid Oxygen (LOX) production and storage areas. Joints and cracks within 25 feet of LOX susceptible areas must be sealed with LOX compatible sealants. If LOX sealants are unavailable, joints and cracks must be kept clean and unsealed.			
10.	Continuously reinforced concrete pavement (CRCP) is to be specified for all new pavements in LOX areas.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 15. PAVEMENTS (CONTINUED)			
D.	FLEXIBLE PAVEMENTS:			
1.	Technical guidance for improvement in the quality of asphaltic concrete pavements is provided in HQ AFESC/DEMP letter, 29 Mar 85, Subject: Improving Asphaltic Concrete (AC) Construction Quality.			
2.	Does design require the use of a "double string-line" method to ensure close control of both longitudinal and transverse grade of paving?			
3.	If pavement recycling is specified, does design conform to the requirements of AFM 88-6, Chapter 6, and Lessons Learned included in HQ AFESC/DEM letter, 31 May 84, Subject: Pavement Recycling.			
4.	Does the specification contain provisions for reducing payment to the contractor when specified quality is not achieved?			
E.	PAVEMENT GROOVING:			
1.	Check design to ensure proper spacing and groove type are specified for both AC and PCC pavements.			
2.	Ensure design eliminates grooving within 300 feet of aircraft arresting barriers.			
F.	SEAL COATS ANY REJUVENATORS FOR FLEXIBLE PAVEMENTS:			
1.	Rejuvenators should not be specified for runway surfaces as they can make pavements extremely slippery.			
2.	Does the design require the use of test strips to assure specified rejuvenators are correctly applied?			
3.	Does the pavement to be rejuvenated contain a minimum of 5 percent voids?			
4.	Pavements subjected to heavy traffic or high tire pressures should not be slurry-sealed due to FOD potential.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
G.	LIST ANY ADDITIONAL LOCALLY UNIQUE R&M DESIGN FEATURES TO BE CNOSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 16. FIRE PROTECTION			
A.	GENERAL - Check:			
1.	That the fire protection system(s), including standpipes, sprinkler, hoses, accessories, and extinguishers for both exterior and interior systems are completely described, drawn, and specified in conformance with appropriate technical manuals and NFPA codes.			
2.	That the fire alarm requirement is coordinated with the electrical central alarm system.			
3.	Is the sprinkler system piping designed to assure free draining to riser drain valves.			
4.	Does the design of nonpotable water storage provide for secondary use so that continual changing is provided?			
5.	Is the fire alarm/detection system compatible with the existing on-base system? System standardization is highly desired.			
6.	Applicable manuals, codes, and standards represent minimum acceptable recuirements, and as such, are not to be considered design goals. Rather, they will typically be exceeded to achieve desired R&M.			
7.	Does the design identify the required fire protection and life safety features such as protection o£ verticle openings, interior finishes, signaling systems, extinguishing systems, segregation or protection of hazardous conditions, smoke partitions, fire doors, and building service equipment?			
8.	Does the design provide for an adequate outside fire protection, including water supply/storage and accessibility by the fire department?			
9.	The location of detail fire alarm system appurtenances and all automatic fire doors, fire and/or smoke dampers, ceiling dampers, and fire protection means of similar nature associated with air duct systems shown on the electrical and mechanical drawings?			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
10.	Is a system provided for the containment and collection of expended extinguishing agents such as AFFF or other dry/wet chemical agents?			
11.	Ensure that suffocating extinguishing agents, such as C0+2,, are not specified in conjunction with munitions or materials containing their own oxygen supply.			
12.	Check that the fire extinguishing system, smoke evacuation systems, and related systems and equipment are designed so that their proper operation does not depend upon a high degree of sophisticated maintenance. A highly reliable and easily maintainable, cost-effective system is the design objective.			
B.	LIST ANY ADDITIONAL LOCALLY UNIQUE R&M DESIGN FEATURES TO BE CONSIDERED:			
1.				
2.				

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 17. CENTRAL HEAT PLANTS			
A.	COAL HANDLlNG AND STORAGE AREA			
1.	Is outside storage area of adequate size to maintain cequired coal at limited pile height?			
2.	Is the storage area designed for rubber-tired vehicles to handle the stockpile?			
3.	If a rail system to the base is available, is a rail receiving area provided? If shipment is by truck, are facilities designed for efficient handling?			
4.	Is the capacity of each piece of conveying equipment installed in series limited to the capacity of the following piece of equipment?			
5.	Is the conveying rate of the coal handling system capable of transporting to live storage in eight hours the maximum daily requirement?			
6.	Are inclined conveyors such as belt, flight, and en masse conveyors kept at a minimum incline to prevent capacity decrease?			
7.	Are hopper angles as steep as practical with an absolute minimum angle of 55 degrees from horizontal? If a square hopper is specified, the valley angle must be 55 degrees minimum.			
8.	Check to ensure that potential dead areas in bunkers are avoided since these areas can promote spontaneous combustion.			
9.	Is appropriate fire prevention and extinction equipment specified?			
10.	Does the design of bunkers and silos provide the capability for evacuation in case of a fire?			
11.	Is the material specified for the construction of storage and handling equipment able to withstand the corrosive effects of coal?			
12.	Screw-type conveyors should not be specified since they tend to change the coal size.			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	OIL HANDLlNG AND STORAGE			
1.	Has a heating system been specified to maintain the oil at a viscosity suitable for handling?			
2.	Is the storage and handling equipment manufactured from materials that will not corrode?			
C.	GAS HANDLING AND STORAGE			
	Are safety valves installed at each boiler to limit gas pressure (one for high limit, one for low)?			
D.	ASH HANDLING			
1.	Are hopper ash valves the zero leak style and designed to open after the ash line vacuum is turned on and close before the ash line vacuum is turned off?			
2.	Does the design provide for separate silos for the storage of fly ash and bottom ash?			
3.	Is fly ash handling system of a dilute phase pneumatic type?			
4.	Does the ash handling system provide that the bottom ash is cool before being handled?			
E.	FANS AND DAMPERS			
1.	Consider control of forced draft and induced draft fans by variable speed motors rather than by mechanical damper positions. This form of control achieves more stable control of furnace draft pressure.			
2.	If common ducting is used between boilers, ensure zero leak dampers are specified to isolate each boiler.			
3.	Are dampers motorized and controlled from inside the heat plant?			
F.	EQUIPMENT			
1.	Are oxygen monitors specified for each boiler outlet in order to determine operations and combustion efficiencies?			
2.	For oil and coal fuels, are opacity and oxygen monitors at each boiler outlet specified?			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	SECTION 17. CENTRAL HEAT PLANTS (CONTINUED)			
3.	Is the wiring for monitors of the shielded type?			
4.	Are monitors of the self-calibrating and self-cleaning type?			
5.	Are the displays and chart devices located on the operating level for easy viewing and maintenance access?			
6.	Is the specified water treatment system of a continuous-feed type with each chemical metered separately?			
7.	Are the maximum heat release rates for coal-fired boilers within the following ranges?			

	Grate Heat Release BTU/HR/SF	Furnace Heat Release BTU/HR/CF
Chain Grate	475,000	32,000
Spreader Stokers		
Dump Grates	400,000	32,000
Cont Cleaning	500,000	25,000
Traveling Grat	650,000	32,000

G.	AIR POLLUTION CONTROL			
1.	Does the design provide mechanical collectors as precleaning devices upstream from baghouses and electrostatic precipators (ESP)?			
2.	Are mechanical collectors designed with manhole access to the collector inlet/outlet and hopper?			
3.	Is the electrical charging and rappers section on the roof of ESPs enclosed and heated to prevent corrosion?			
4.	Are the baghouse and ESP hoppers heated to prevent c]inkering and the area around the hoppers enclosed?			
5.	Are baghouses designed in modules so they can be taken off-line for maintenance while the boiler is still on-line?			
6.	Are ESPs designed with three fields in series with aspect ratio no less than 1.5?			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
7.	To avoid acid corrosion in downstream equipment, are the heat recovery devices of the proper size? The minimum temperature entering air pollution control devices should be 350 degrees F.			
H.	LIST ANY ADDITIONAL LOCALLY UNIQUE R&M DESIGN FEATURES TO BE CONSIDERED:			
1.				
2.				

REPLY TO
ATTN OF:

SUBJ: Reliability and Maintainability (R&M) Program - Lessons Learned

TO: HQ AFESC/DEMM
Tyndall AFB FL 32403-6001

1. To enhance the quality and performance of facilities and supporting systems, the following "lessons learned" supporting the principles of the Air Force R&M program is provided for information and appropriate action.

a. Facility/System Data.

(1) Location (AFB) _____

(2) Building Number _____

(3) Project Title _____

(4) Construction Program (MCP, O&M. Etc) _____

(5) Fiscal Year Programmed _____

(6) Year Constructed _____

b. Description of Problem/Success: _____
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c. Recommended Action: _____
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2. Name, Address and Phone Number of Originator: _____
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Atch 2