ERDC
INNOVATIVE SOLUTIONS
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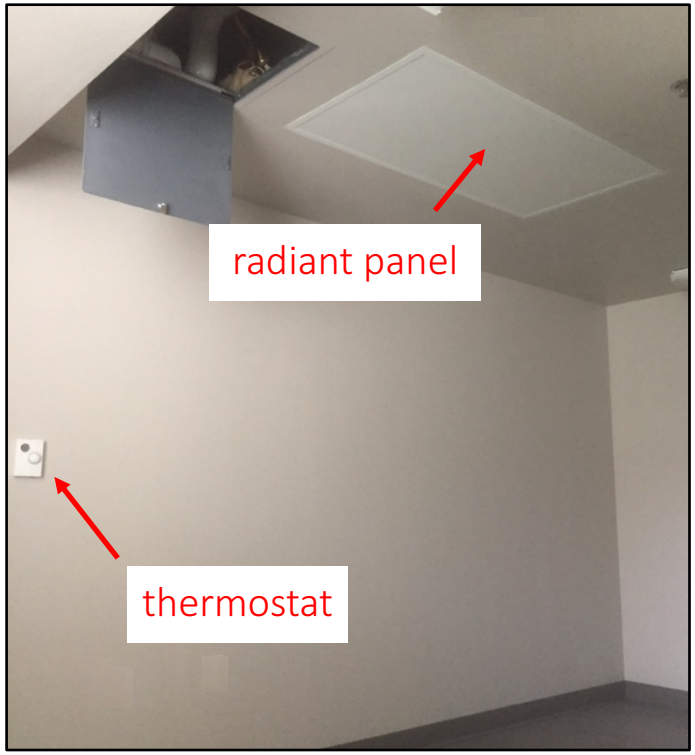
IEA EBC Annex 61
Deep Energy Retrofit of Buildings Forum
16SEP16

DER Mechanical Quality Assurance

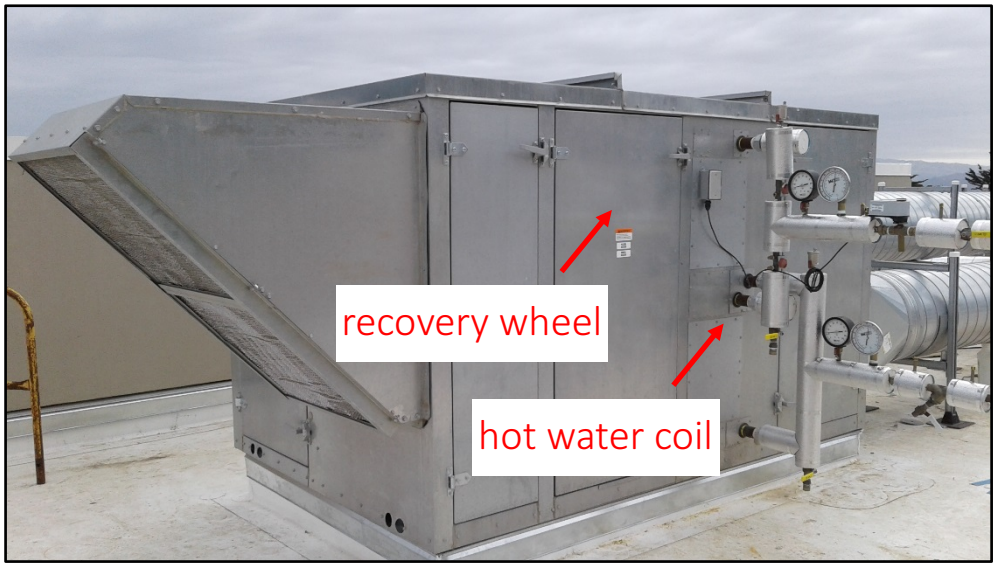
Brian Clark, PE, CEM, CPMP
US Army Corps of Engineers
Construction Engineering Research Laboratory

Presidio DER barracks uses simple zone and air-side HVAC strategies

Low temperature radiant hot water



Dedicated outside air system (DOAS)



However, hydronic plant is complex

Greywater heat recovery

Stratified hot water tanks

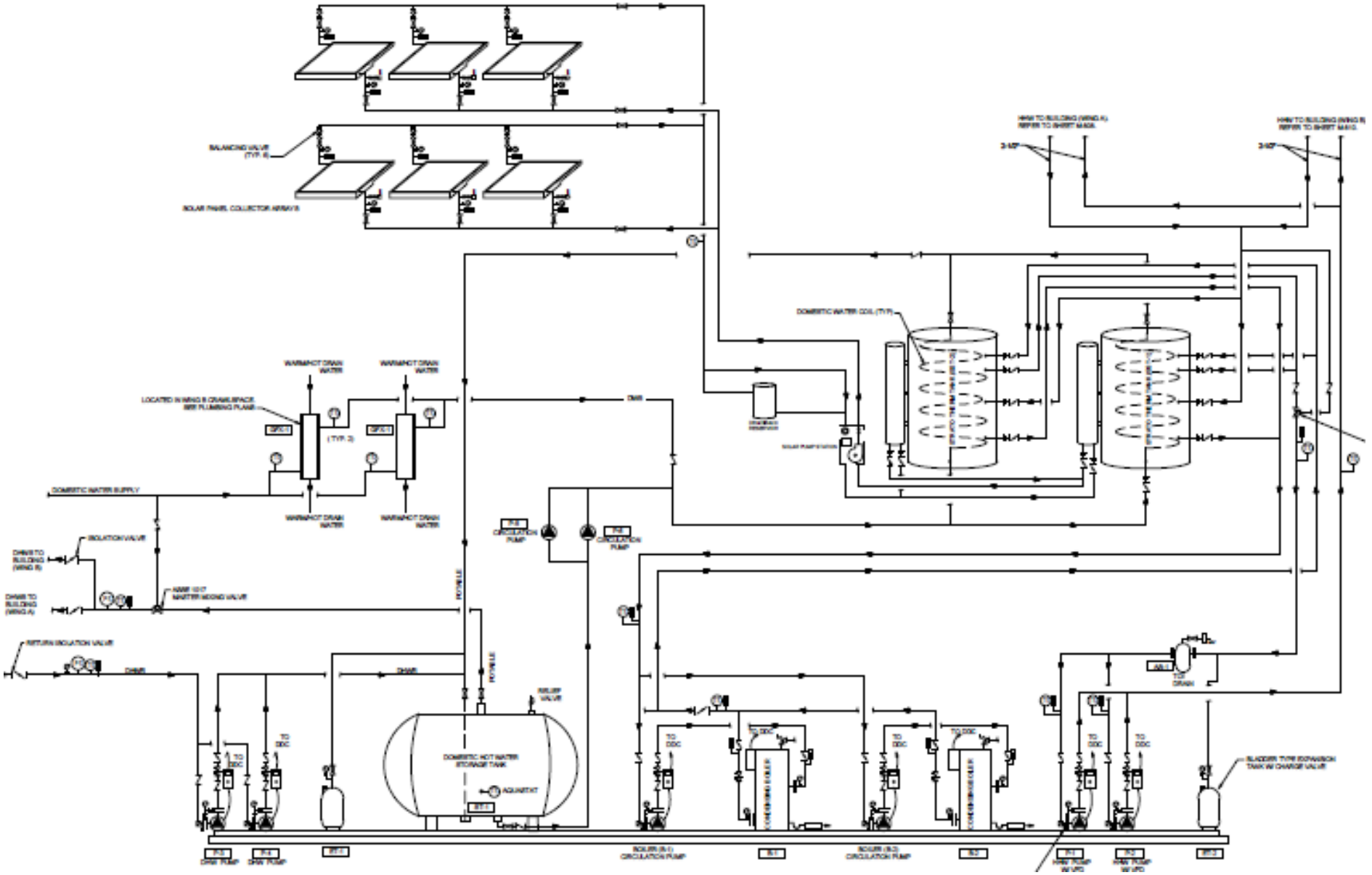
Solar thermal system

Condensing hot water boilers

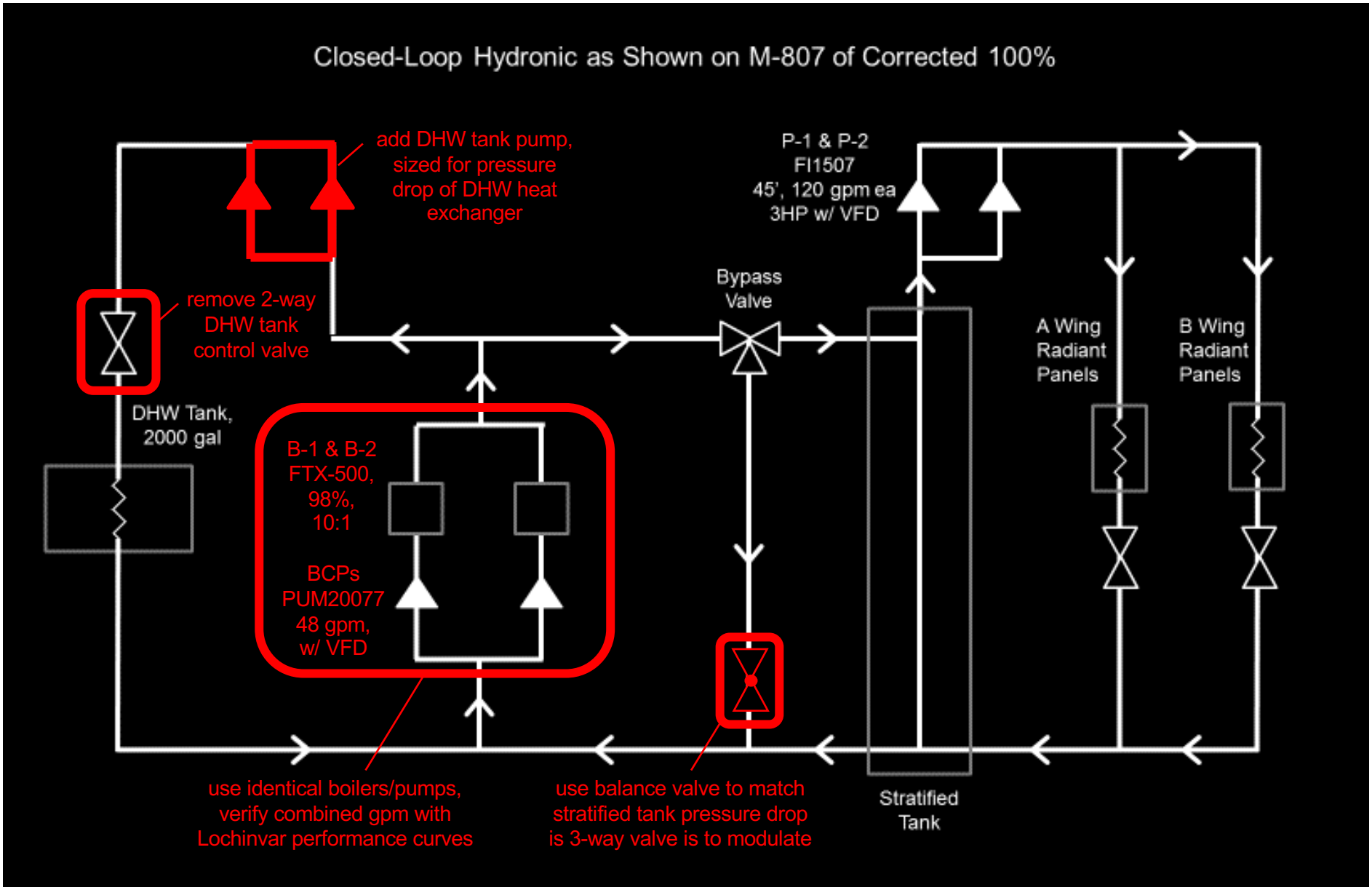
Variable speed distribution

Domestic hot water storage and return

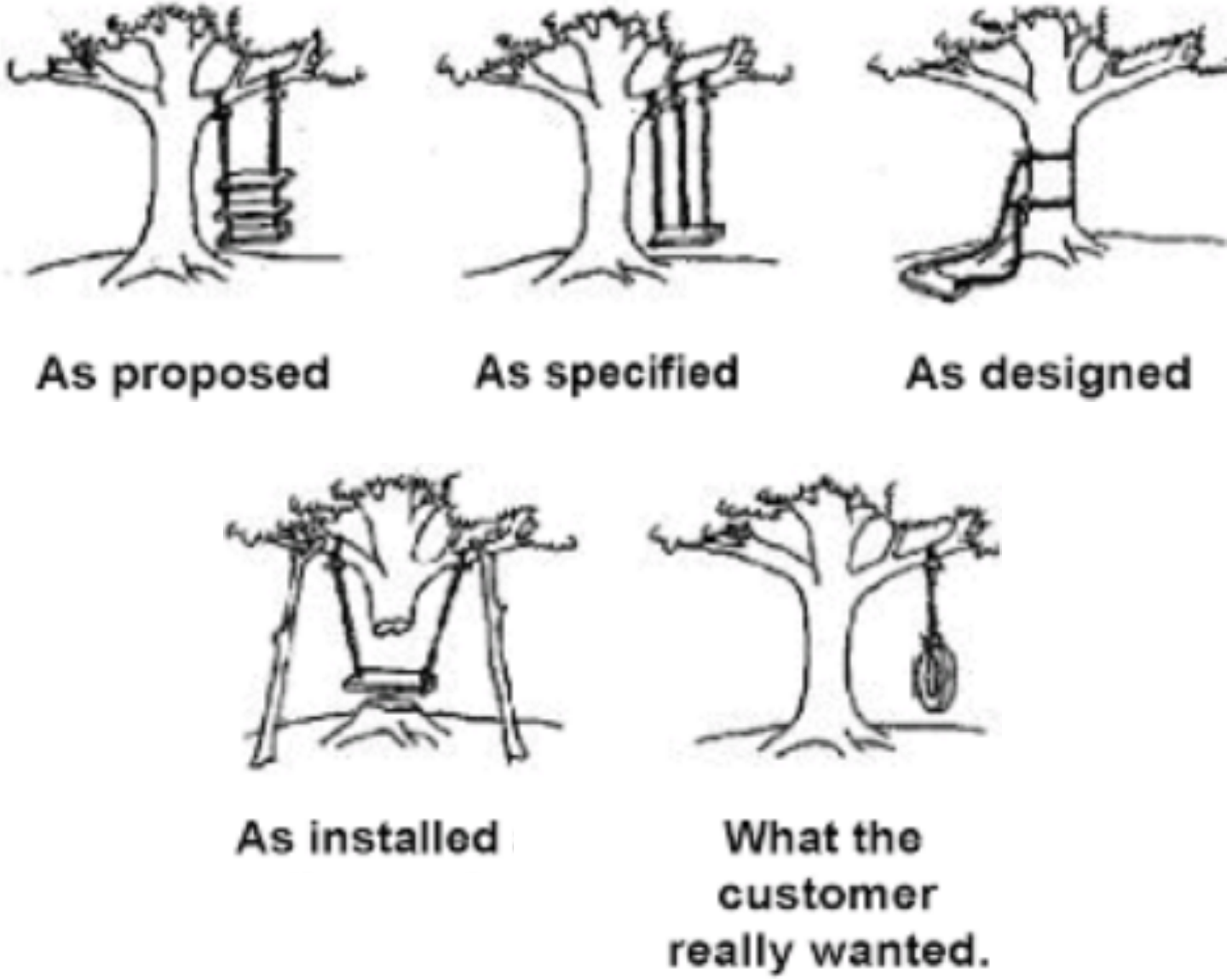
This complexity poses special DER QA challenges



Strategic DER QA tools and methods are needed



Quality Assurance covers all project phases

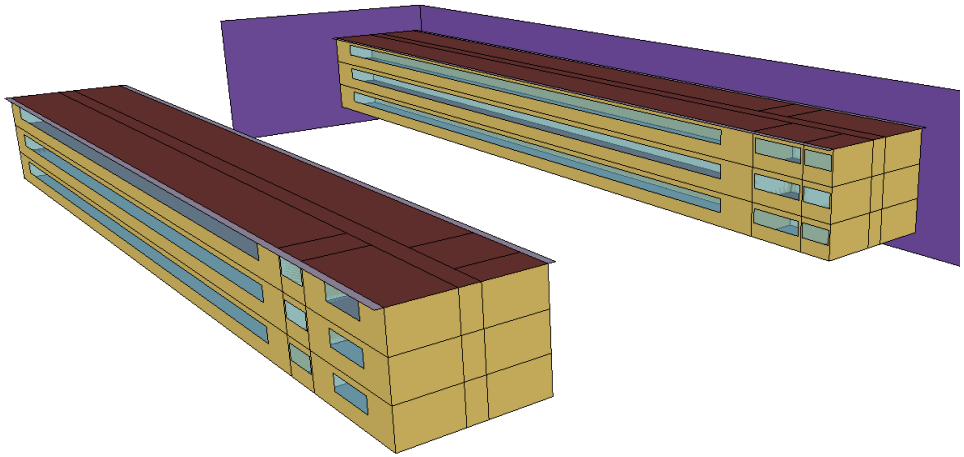


DER QA starts with energy modeling

national average or local utility: 3.140 vs 2.722 for electricity

$$\text{Source Energy Use Intensity (EUI) Requirement} = \frac{\textit{Site Energy x Site-to-Source Factor}}{\textit{Conditioned Square Footage}} = 60\,\frac{kBtu}{SF}\ (189\,\frac{kWh}{m^2})$$

include new chases and vestibules: 72KSF vs 63KSF



- provide load profiles, occupant schedules, and space designations
- indicate any modeling exemptions for disabled equipment or diversity
- defined required approaches to modeling advanced HVAC sequences
- require new models at each design iteration or usage/equipment change

Drafting the DER RFP requires balance

Prescriptive Requirements

- Modeling assumptions
- Energy system types
- Component efficiencies
  - HVAC equipment
  - Renewable/heat recovery types
  - Lighting technology/controls
  - Window types/details
  - HVAC controls interface needs

Performance Requirements

- Site/Source EUI
- Energy system configurations
- Performance/test procedures
  - ASHRAE 90.1-2013
  - Production capacities/locations
  - IESNA 90.1-2013
  - Assembly U-values, USACE leakage
  - PVT endurance test

Provide as much HVAC controls detail as possible

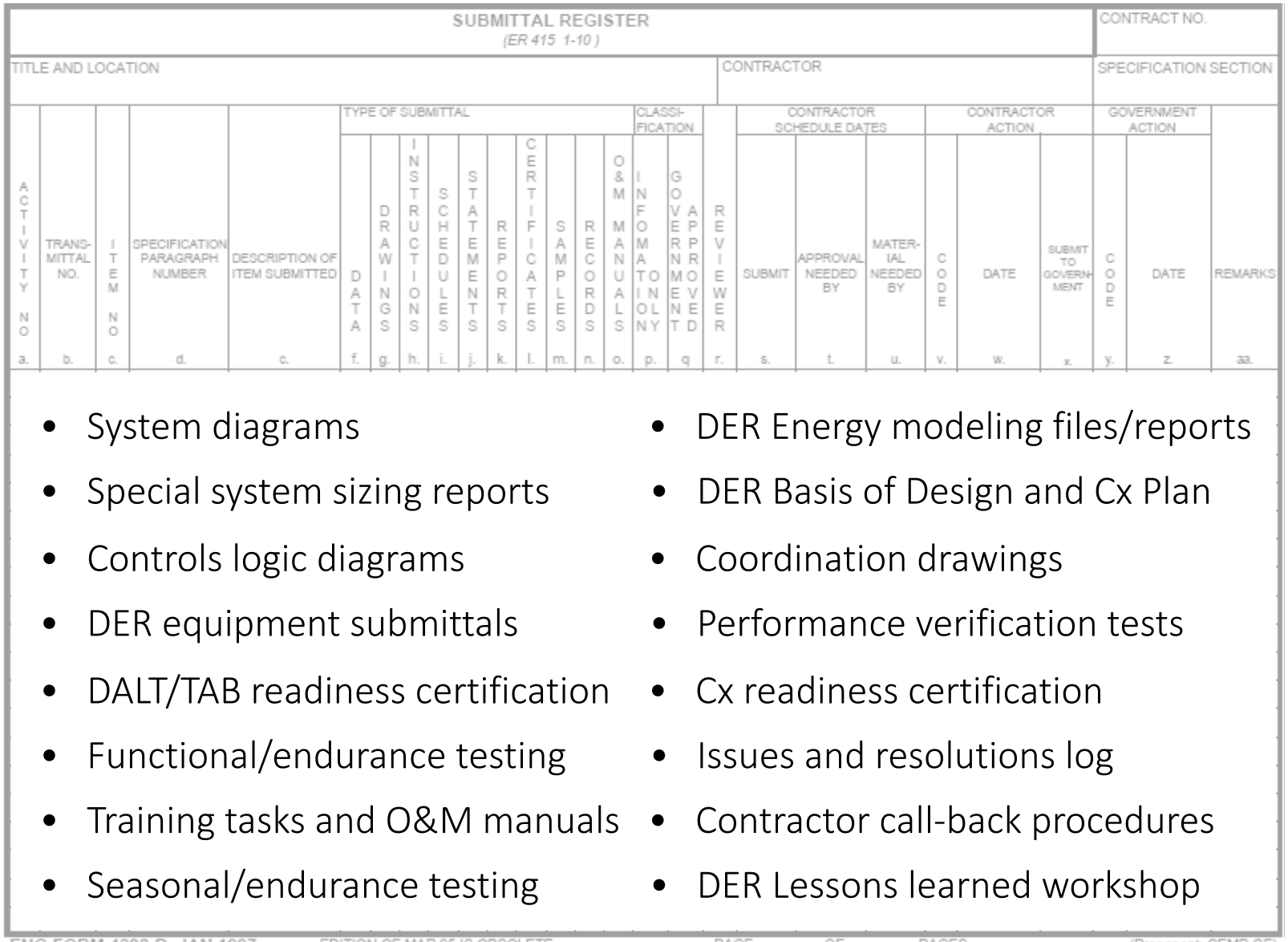
standardize naming conventions

Decide how control system will be used

establish desired setpoints and
control strategies vs design needs

DOAS Points Schedule									
	Point Types					Point Uses			
Function	Name	Description	Setting	Range	IO Type	Display	Override	Trend	Alarm
Proofs & Safeties	SF-S	Supply Fan Status	~	ON/OFF	BI	local, UMCS	~	15 m	Proof Fails
	EF-S	Exhaust Fan Status	~	ON/OFF	BI	local, UMCS	~	15 m	Proof Fails
	SA-P-HL	Supply Air Pressure High Limit	(Design)	ALM/NML	~	~	UMCS	~	> Setting
Start / Stop	SYS-OCC	Occupancy Input (from UMCS)	~	(24/7)	NVI	UMCS	UMCS	~	~
	SF-SS	Supply Fan Start/Stop	~	ON/OFF	BO	local, UMCS	local, UMCS	~	~
	EF-SS	Exhaust Fan Start/Stop	~	ON/OFF	BO	local, UMCS	local, UMCS	~	~
Flow Control	SA-P	Duct Supply Air Pressure	~	~	AI	local, UMCS	~	15 m	~
	SA-P-SP	Duct Supply Air Pressure Set Point	(Design)	~	AO	local, UMCS	UMCS	~	~
	SF-C	Supply Fan Command	~	0-100%	AO	local, UMCS	local, UMCS	~	~
	EA-F	Exhaust Air Flow	~	~	AI	local, UMCS	~	15 m	~
	EA-F-DIFF-SP	Exhaust Fan Flow Difference Set Point	(Design)	~	~	UMCS	UMCS	~	~
Temperature Control	SAT-T	Supply Air Temperature	~		AO	local, UMCS	~	15 m	~
	SAT-T-SP	Supply Air Temperature Set Point	Reset	65-72F	AO	local, UMCS	UMCS	~	> 80F
	OA1-T	Outside Air Temperature (at HX Inlet)	~	~	AI	local, UMCS	~	5 m	~
	EA1-T	Exhaust Air Temperature (at HX Inlet)	~	~	AI	local, UMCS	~	5 m	~
	OA2-T	Outside Air Temperature (at HX Discharge)	~	~	AI	local, UMCS	~	5 m	~
	EA2-T	Exhaust Air Temperature (at HX Discharge)	~	~	AI	local, UMCS	~	5 m	~
	HX-BYP	Heat Exchanger Bypass Command	~	ON/OFF	BO	local, UMCS	~	1 m	~

Leverage Submittal Register for better DER QA



SUBMITTAL REGISTER
(ER 415 1-10)

CONTRACT NO.

TITLE AND LOCATION | CONTRACTOR | SPECIFICATION SECTION

ACTIVITY NO a.	TRANSMITTAL NO. b.	ITEM NO c.	SPECIFICATION PARAGRAPH NUMBER d.	DESCRIPTION OF ITEM SUBMITTED e.	TYPE OF SUBMITTAL: DATA f.	DRAWINGS g.	INSTRUCTIONS h.	SCHEDULES i.	STATEMENTS j.	REPORTS k.	CERTIFICATES l.	SAMPLES m.	RECORDS n.	O&M MANUALS o.	CLASSIFICATION: INFO ONLY p.	GOVERNMENT APPROVED q.	REVIEWER r.	CONTRACTOR SCHEDULE DATES: SUBMIT s.	APPROVAL NEEDED BY t.	MATERIAL NEEDED BY u.	CONTRACTOR ACTION: CODE v.	DATE w.	SUBMIT TO GOVERNMENT x.	GOVERNMENT ACTION: CODE y.	DATE z.	REMARKS aa.

- System diagrams
- Special system sizing reports
- Controls logic diagrams
- DER equipment submittals
- DALT/TAB readiness certification
- Functional/endurance testing
- Training tasks and O&M manuals
- Seasonal/endurance testing
- DER Energy modeling files/reports
- DER Basis of Design and Cx Plan
- Coordination drawings
- Performance verification tests
- Cx readiness certification
- Issues and resolutions log
- Contractor call-back procedures
- DER Lessons learned workshop

ENG FORM 4288-R, JAN 1997 EDITION OF MAR 95 IS OBSOLETE. PAGE ____ OF ____ PAGES (Proponent: CEMP-CE)
PE v1.00

QA capabilities: who understands…

renovation space constraints issues?

solar tilt, piping, and shading effects?

duct air leakage testing procedures?

effects of poor controls installation?

Well-written Functional Performance Tests are key

Purpose: what are we validating?

(some OPR, performance, or sequence of operation requirement)

Prerequisites:

(eg, certificate of readiness after PVT, TAB, pre-functional checks)

Precautions:

(safety measures, coordination needs, emergency procedures)

Required Participants:

(such as Cx specialists, O&M reps, designers, subcontractors, or QA rep)

Required Equipment:

(testing instrumentation needed and sample of components to be tested)

Step-by-Step Procedure:

(list of results from each sequence of operation change)

Acceptance Criteria:

(some percentage or threshold above requirement, else 100% as required)

Supply DER system performance test forms (or verify each sequences is being tested)

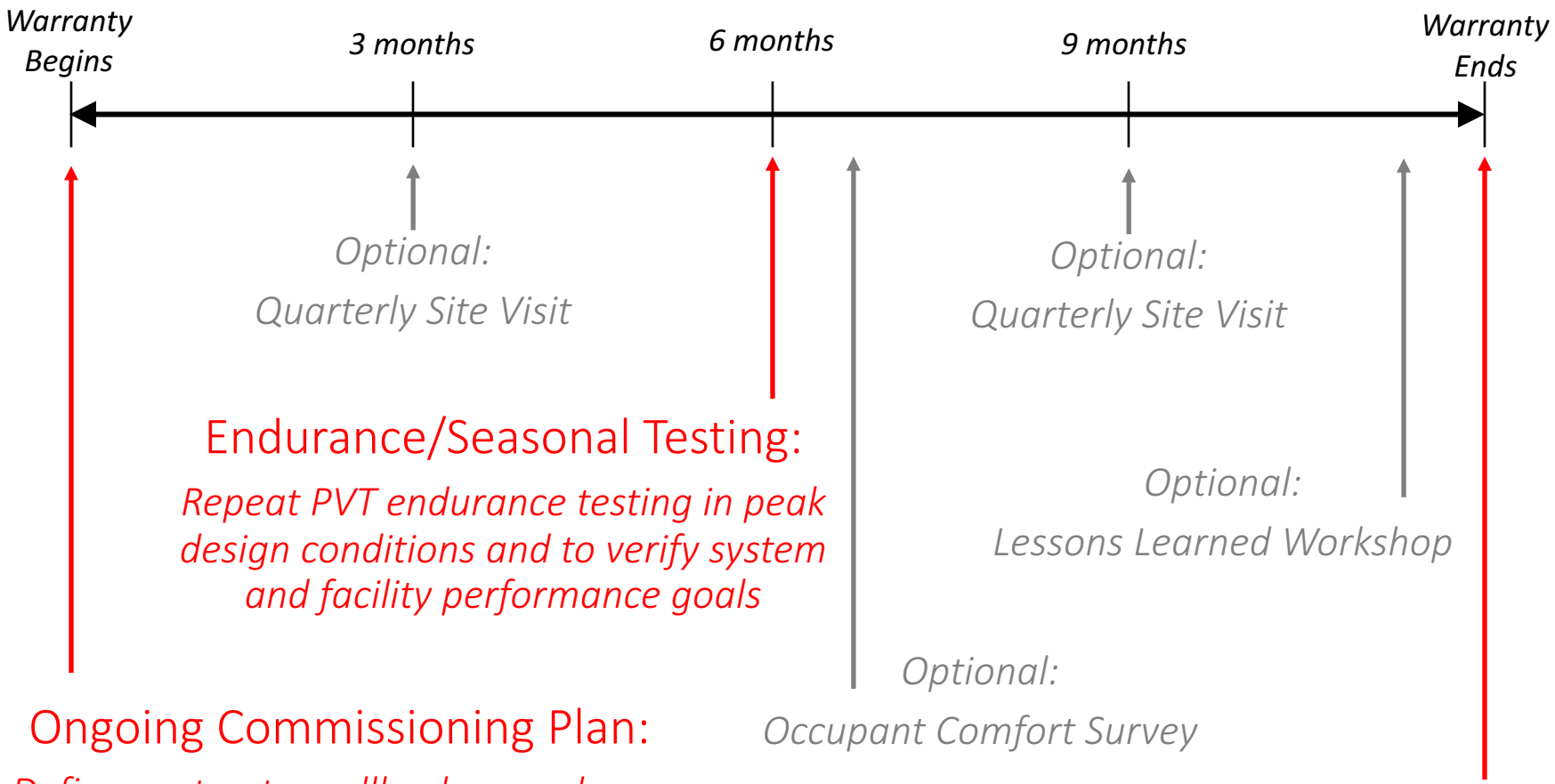
G. Test Procedures

Sequence of Operation for Procedures No. 13.01 through 13.04:

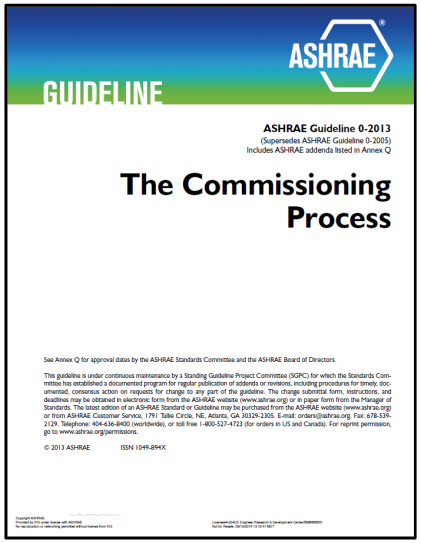
-TANK CIRCULATION PUMPS WILL OPERATE OF THERMAL SENSING ELEMENT IN THE DOMESTIC STORAGE TANK. THERMAL SENSING ELEMENT WILL BE A 1K SENSOR IN A 3/4" BRASS WELL. WATER TEMPERATURE WILL BE SET TO 140*F (ADJUSTABLE). P-5 WILL BE THE PRIMARY PUMP, P-6 WILL BE BACK-UP IF P-5 WERE TO FAIL. EACH PUMP WILL HAVE A CT SENSOR FOR SIGNAL STATUS.

Procedure No.	Test Procedure	Expected Response	Pass Y/N
13.01	Set P-5 to be the lead pump. Record current tank temperature: _____ °F Set 'tank setpoint' to 10°F greater than the current tank temperature: _____ °F	P-5 should start. Verify P-5 run status at the EMCS.	
13.02	Turn off P-5 at its disconnect switch or remove on/off wire as needed to simulate a pump failure.	P-5 status should be lost at the EMCS, and P-6 should start. Verify P-6 run status at the EMCS.	
13.03	Set P-6 to be the lead pump. Turn P-5 back on or reconnect wire as needed. Turn off P-6 at its disconnect switch or remove on/off wire as needed to simulate a pump failure.	P-6 status should be lost at the EMCS, and P-5 should start.	
13.04	Set 'tank setpoint' to 10°F less than the current tank temperature: _____ °F Return all parameters to their pre-test value. See Paragraph F above.	P-5 should stop.	
Comments:			

Include DER project follow-up requirements



Several frameworks existing for documenting enhanced QA requirements


ASHRAE

GUIDELINE

ASHRAE Guideline 0-2013

(Supersedes ASHRAE Guideline 0-2005)
Includes ASHRAE addenda listed in Annex Q

The Commissioning Process

See Annex Q for approval dates by the ASHRAE Standards Committee and the ASHRAE Board of Directors.

This guideline is under continuous maintenance by a Standing Guideline Project Committee (SGPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the guideline. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard or Guideline may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

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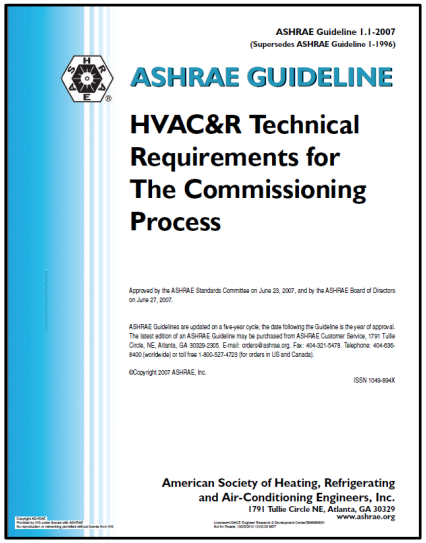
ASHRAE Guideline 1.1-2007
(Supersedes ASHRAE Guideline 1-1996)

ASHRAE GUIDELINE

HVAC&R Technical Requirements for The Commissioning Process

Approved by the ASHRAE Standards Committee on June 29, 2007, and by the ASHRAE Board of Directors on June 27, 2007.

ASHRAE Guidelines are updated on a five-year cycle; the date following the Guideline is the year of approval. The latest edition of an ASHRAE Guideline may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide) or toll free 1-800-527-4723 (for orders in US and Canada).

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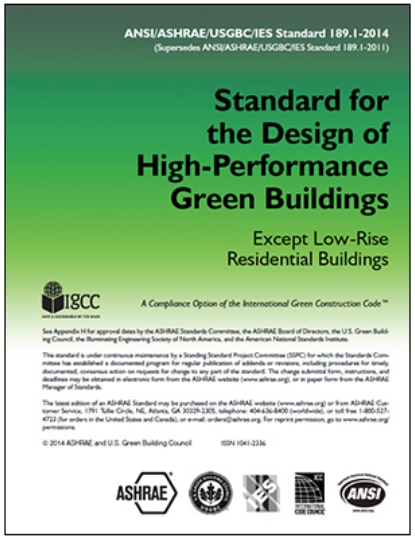
ANSI/ASHRAE/USGBC/IES Standard 189.1-2014

(Supersedes ANSI/ASHRAE/USGBC/IES Standard 189.1-2011)

Standard for the Design of High-Performance Green Buildings

Except Low-Rise Residential Buildings

IGCC

A Compliance Option of the International Green Construction Code™

See Appendix H for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the U.S. Green Building Council, the Illuminating Engineering Society of North America, and the American National Standards Institute.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org), or in paper form from the ASHRAE Manager of Standards.

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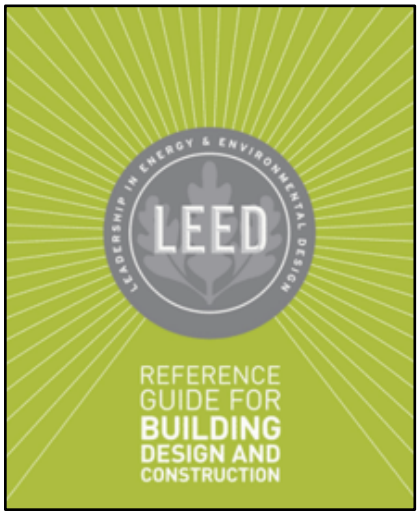
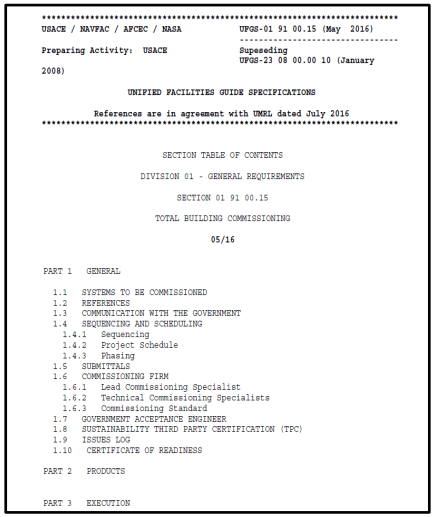
ASHRAE ANSI




USACE / NAVFAC / AFCEC / NASA UPGS-01 91 00.15 (May 2016)

Preparing Activity: USACE Superseding UPGS-23 08 00.00 10 (January 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2016

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DIVISION 01 - GENERAL REQUIREMENTS

SECTION 01 91 00.15

TOTAL BUILDING COMMISSIONING

05/16

PART 1 GENERAL

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1.3 COMMUNICATION WITH THE GOVERNMENT
1.4 SEQUENCING AND SCHEDULING
1.4.1 Sequencing
1.4.2 Project Schedule
1.4.3 Phasing
1.5 SUBMITTALS
1.6 COMMISSIONING FIRM
1.6.1 Lead Commissioning Specialist
1.6.2 Technical Commissioning Specialists
1.6.3 Commissioning Standard
1.7 GOVERNMENT ACCEPTANCE ENGINEER
1.8 SUSTAINABILITY THIRD PARTY CERTIFICATION (TPC)
1.9 ISSUES LOG
1.10 CERTIFICATE OF READINESS

PART 2 PRODUCTS

PART 3 EXECUTION


US Army Corps of Engineers

ENGINEERING AND CONSTRUCTION BULLETIN

No. 2015-6 Issuing Office: CECW-CE Issued: 19 Feb 2015 Expires: 19 Feb 2017

Subject: Total Building Commissioning Process for USACE Projects

Applicability: Directive & Guidance

References:

a. AR 420-1, Army Facilities Management.
b. ER 1110-345-723, Systems Commissioning Procedures.
c. ER 25-345-1, Systems Operation and Maintenance Documentation.
d. ER 414-345-38, Transfer and Warranty.
e. ER 37-1-30, Financial Administration - Accounting and Reporting.
f. U.S. Green Building Council (USGBC) LEED Reference Guide for Green Building Design and Construction 2009 Edition.
g. Memorandum, ASA (IE&E), 16 Dec 2013, subject: Sustainable Design and Development Policy Update.
h. ECB 2012-14, 23 Apr 2012, subject: Update to High Performance Energy and Sustainability, Leadership in Energy and Environmental Design (LEED) Certification Guidance.
i. ECB 2013-5, 13 Feb 2013, subject: Continuity of the High Performance Energy and Sustainability Policy.
j. ASHRAE Guideline 0-2005, The Commissioning Process.
k. ASHRAE Guideline 189.1-2011 Standard for the Design of High Performance Green Buildings, Section 10 Construction and Plans for Operations.
l. Unified Facilities Criteria 1-200-02, 1 March 2013, subject: High Performance and Sustainable Building Requirements.
m. High Performance and Sustainable Buildings Guidance, 1 Dec 2008.

1. **Purpose:** This ECB establishes the requirements for and provides information and guidance on Total Building Commissioning Processes on Army projects for Engineers, Project Managers and Construction Managers. USACE currently performs commissioning on all projects per Systems Commissioning Procedures ER 1110-345-723 (Reference b). This ECB provides a review of the Corps' existing processes, additional tasks and additional building systems needed beyond our existing commissioning processes to meet the new requirements of Total Building Commissioning. Currently the Corps existing processes address the majority of tasks needed to comply with total building commissioning. There are four tasks identified as new or in our current process but need augmentation 1)NEW: the designation of a USACE Commissioning Authority and supporting Commissioning team in the predesign/design phase (see section 4 of this ECB), 2) **AUGMENT**:

Roles & Responsibilities chart provides framework for *who, what, when* of Cx

When:

Phase and Sequencing

(Design tasks shown)

What:

L: Lead — R: Review

P: Participate — *O: Optional*

A: Approve: — *N/A: Not Applicable*

Category	Task Description	CxG	COR	CxD	DOR	CxC	O&M
Coordination Cx Plan & Spec Schedules	Coordinate with [COR, AHJ, Vendors, etc.] to ensure that Cx interacts properly with other systems as needed to support OPR and BoD	P	P	N/A	L	P	P
	Preliminary Commissioning Plan	R	A	N/A	R	L	P
	Preliminary Cx Specifications	R	A	N/A	R	L	P
	Design Phase Commissioning Schedule	R	A	N/A	L	P	P
OPR and BoD	Maintain OPR on behalf of Owner	P	P	N/A	L	P	P
	Review Basis of Design Document vs. OPR	R	P	N/A	P	L	P
	Maintain BoD on behalf of Owner	P	P	N/A	L	P	P
Reviews	Focused Concept Design Review	R	A	N/A	L	R	P
	Focused Design Development (35-50%) Review	R	A	N/A	L	R	P
	Focused Construction Document Review	R	A	N/A	L	R	P
	Focused Pre-Final Construction Document	R	A	N/A	L	R	P
	Focused Final Construction Document	R	A	N/A	L	R	P
	Final Construction Document Comment Backcheck	R	A	N/A	L	R	P
Functional Test Protocols	Draft Pre-Functional Construction Checklists (PFC)	R	P	N/A	R	L	P
	Draft System Functional Performance Tests (FPT)	R	P	N/A	R	L	P

Note: *(Appendix C) is just a sample to depict how such a matrix would be developed. There are many more commissioning tasks to be identified beyond identifies. The type of involvement shown is for instruction purposes only and would need to be developed on a project by project basis for the size, comp rigor required.*

Who:

CxG: Government Cx Specialist

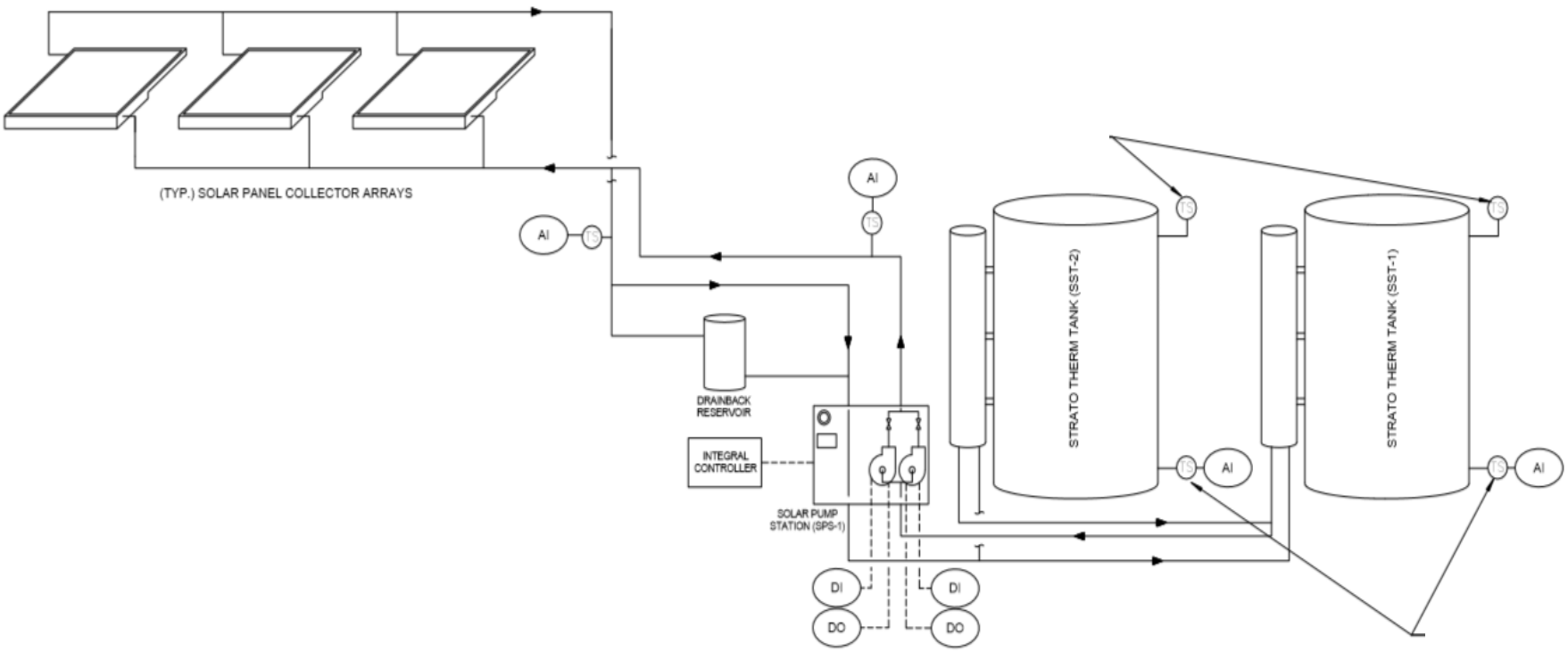
COR: Contracting Officer Rep

CxD: Design Cx Specialist

CxC: Construction Cx Specialist

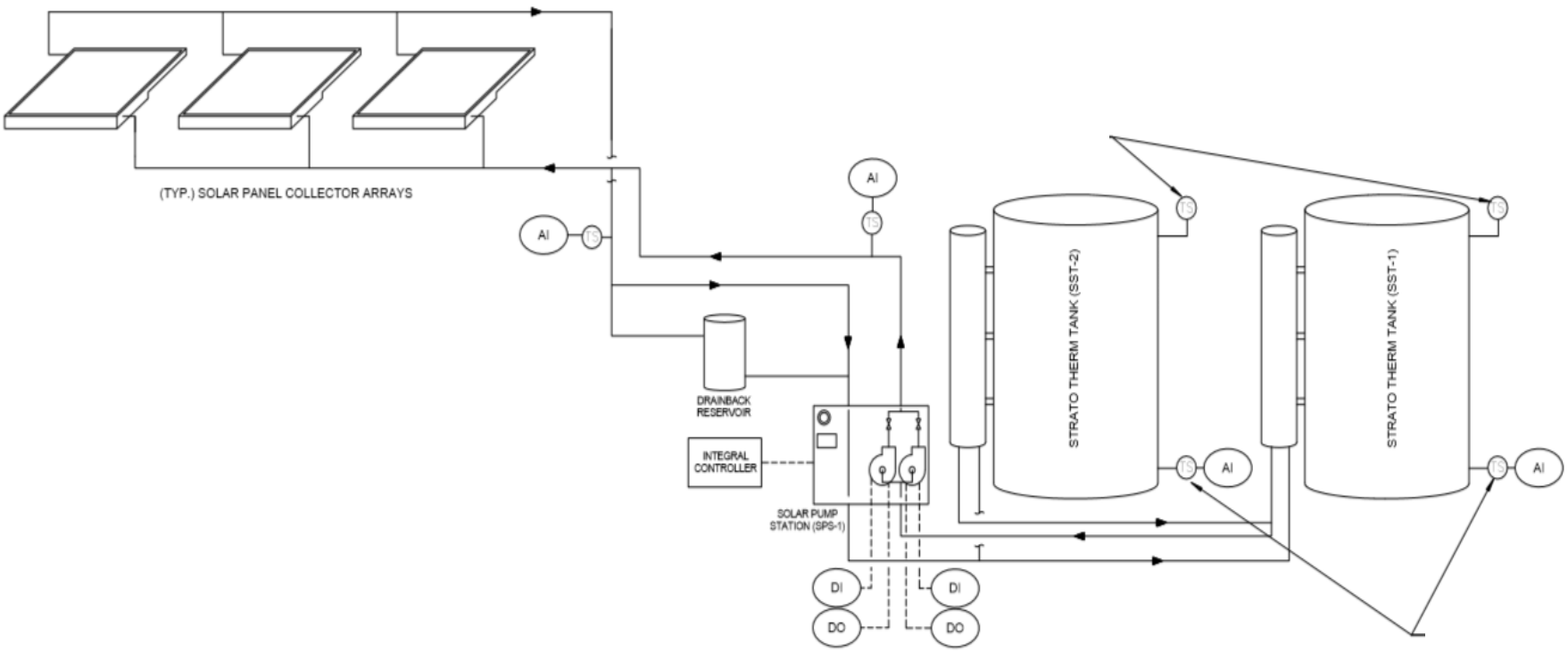
O&M: Facility O&M Technician

Putting it together: SHW example



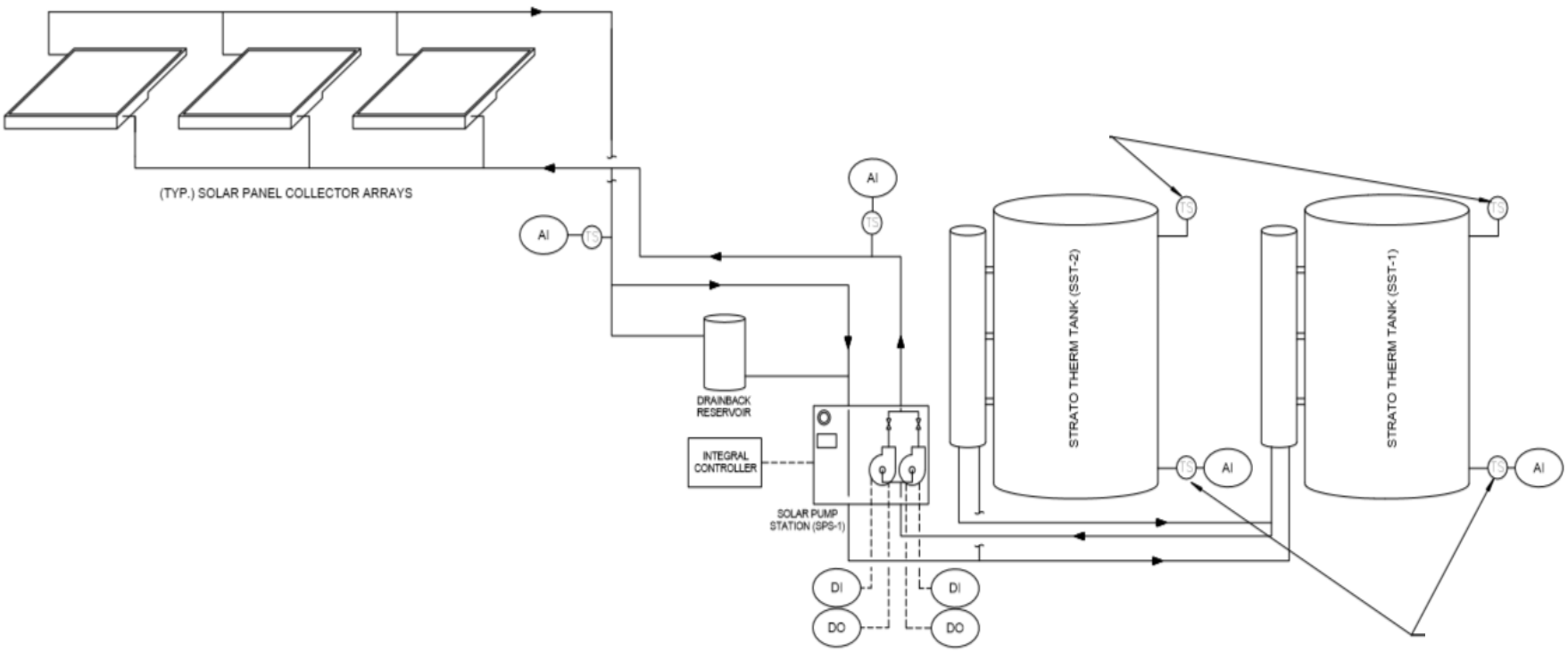
Phase	Task Description	CxG	COR	CxD	DOR	CxC	O&M
Develop-ment	Hold OPR workshop and discuss SHW performance goals, operational concerns, and training needs	L	P	N/A	N/A	N/A	P
	Establish SHW targets and required modeling assumptions (weather, irradiance, efficiencies, etc)	L	O	N/A	N/A	N/A	O
	Use HVAC controls points lists that indicate SHW alarm, trend, graphics, and sequences desired	L	O	N/A	N/A	N/A	R
	Select design checklists, functional performance tests sheets, and O&M data required in future phases	L	O	N/A	N/A	N/A	P
	Integrate SHW requirements into final OPR, submittal register, Cx Plan, and RFP documents	L	R	N/A	N/A	N/A	R

Similar approach for design with CxD support



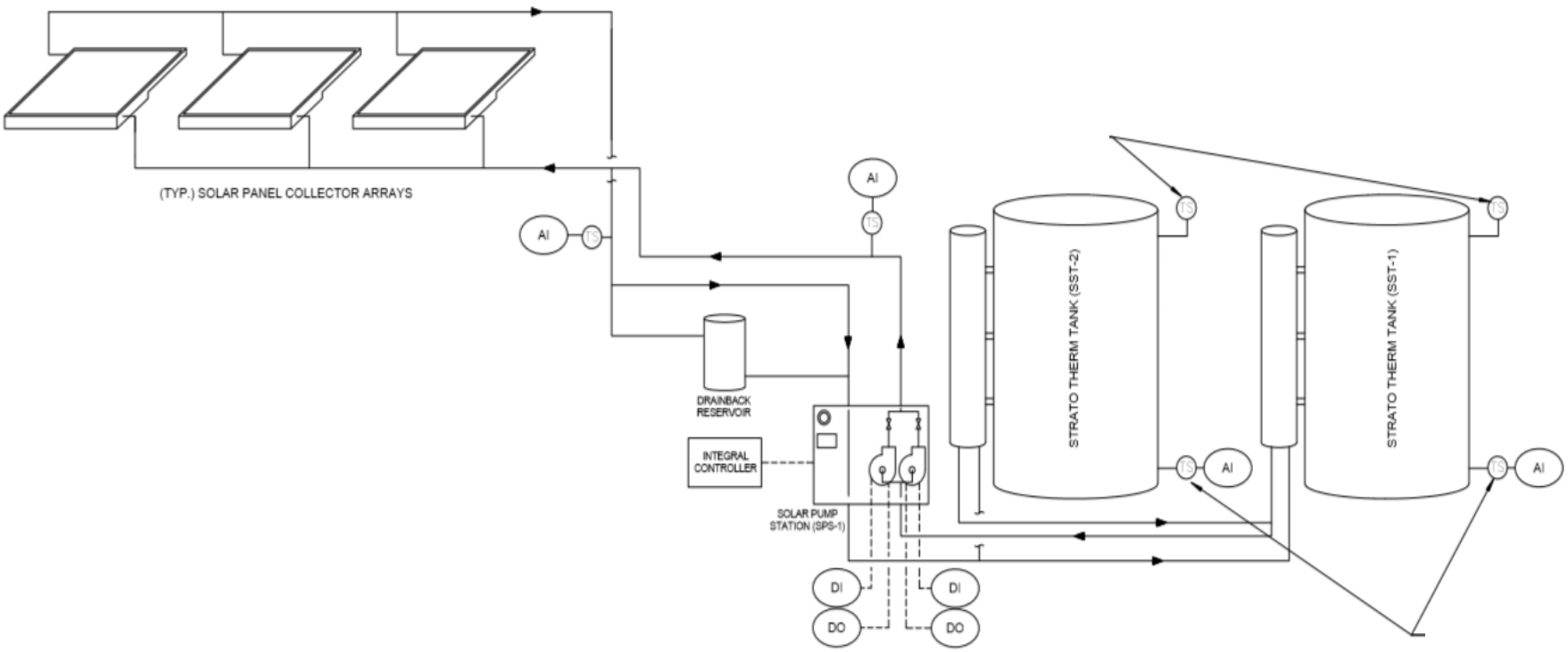
Phase	Task Description	CxG	COR	CxD	DOR	CxC	O&M
Design	Participate in solicitation board review using experience criteria for DER and SHW projects	P	L	N/A	N/A	N/A	N/A
	Document all SHW sizing assumptions, criteria, calculations, and approaches in BOD	R	R	R	L	N/A	N/A
	Provide final SHW modeling (eg, RETscreen) modeling screenshots showing all input/output fields	R	R	R	L	N/A	O
	Develop plans with SHW mounting details (w/ breaks), pump data, and panel shading by azimuth	R	R	R	L	N/A	R
	Develop coordination drawings that show SHW equipment mounting and piping (with insulation)	R	R	L	R	N/A	R
	Develop SHW control sheets with enables, setpoints, freeze/drain protection, points lists, and logic	R	R	R	L	N/A	R
	Complete design SHW checklists that validate all Cx Plan, RFP, and OPR requirements	R	R	L	O	N/A	O

All Cx team roles support construction phase



Phase	Task Description	CxG	COR	CxD	DOR	CxC	O&M
Construc-tion	Hold preparatory Cx meetings prior to installation to review SHW coordination/design/control sheets	P	P	P	N/A	L	O
	Submittal review for all SHW products using RFP, OPR, and design criteria given	R	L	O	O	R	O
	PVT/TAB procedures, testing, and report review for SHW including endurance test requirements	R	L	R	O	R	O
	Perform/Evaluate SHW Pre-functional & Functional Performance Tests after Certificate of Readiness	P	R	R	R	L	P
	Maintain Issues & Resolutions Log to document for all SHW problems and corrective action taken	R	R	O	O	L	N/A
	Execute SHW training plan to review SHW operation/maintenance and provide Systems Manuals	P	R	P	P	L	P

Define post-occupancy Cx requirements early



Phase	Task Description	CxG	COR	CxD	DOR	CxC	O&M
On-going Cx	Develop OCx Plan, maintain Issues & Resolutions Log, and coordinate contractor callbacks	R	R	N/A	N/A	L	P
	Perform seasonal and/or endurance test of SHW system through targeting FPT and trending	P	R	O	O	L	P
	Occupant Comfort survey of hot water system (use e-survey methods and ASHRAE 55 critieria)	R	R	O	O	L	R
	Host on-site Lessons Learned Workshop to discuss and document all SHW best practices and lessons	P	P	P	P	L	P
	Develop OCx Report with final Issues Log, measured EUI, and corrective/RCx actions recommended	R	R	O	O	L	R

Summary DER Mechanical QA Recommendations:

- Define Cx standard and integrate into RFP and Cx Plan
- Add DER documentation requirements to submittal register
- Balance of prescriptive vs performance-based requirements
- Provide points schedule and performance test sheets if possible
- Provide designer and QA technician training on DER methods
- Develop DER COE or leverage existing envelope and Cx COEs
- Compile and evaluate DoD DER projects

More to come on Presidio Barracks 630

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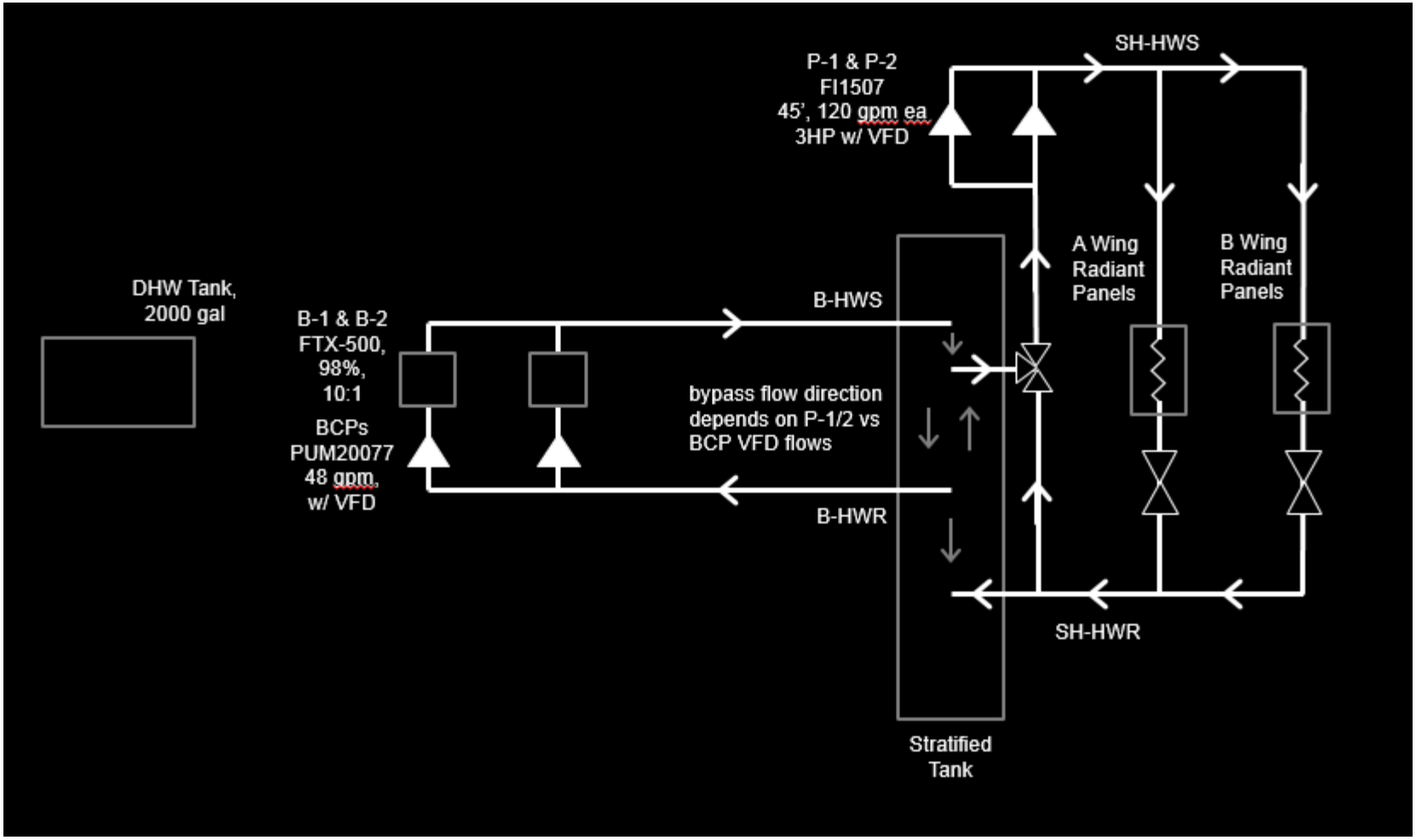
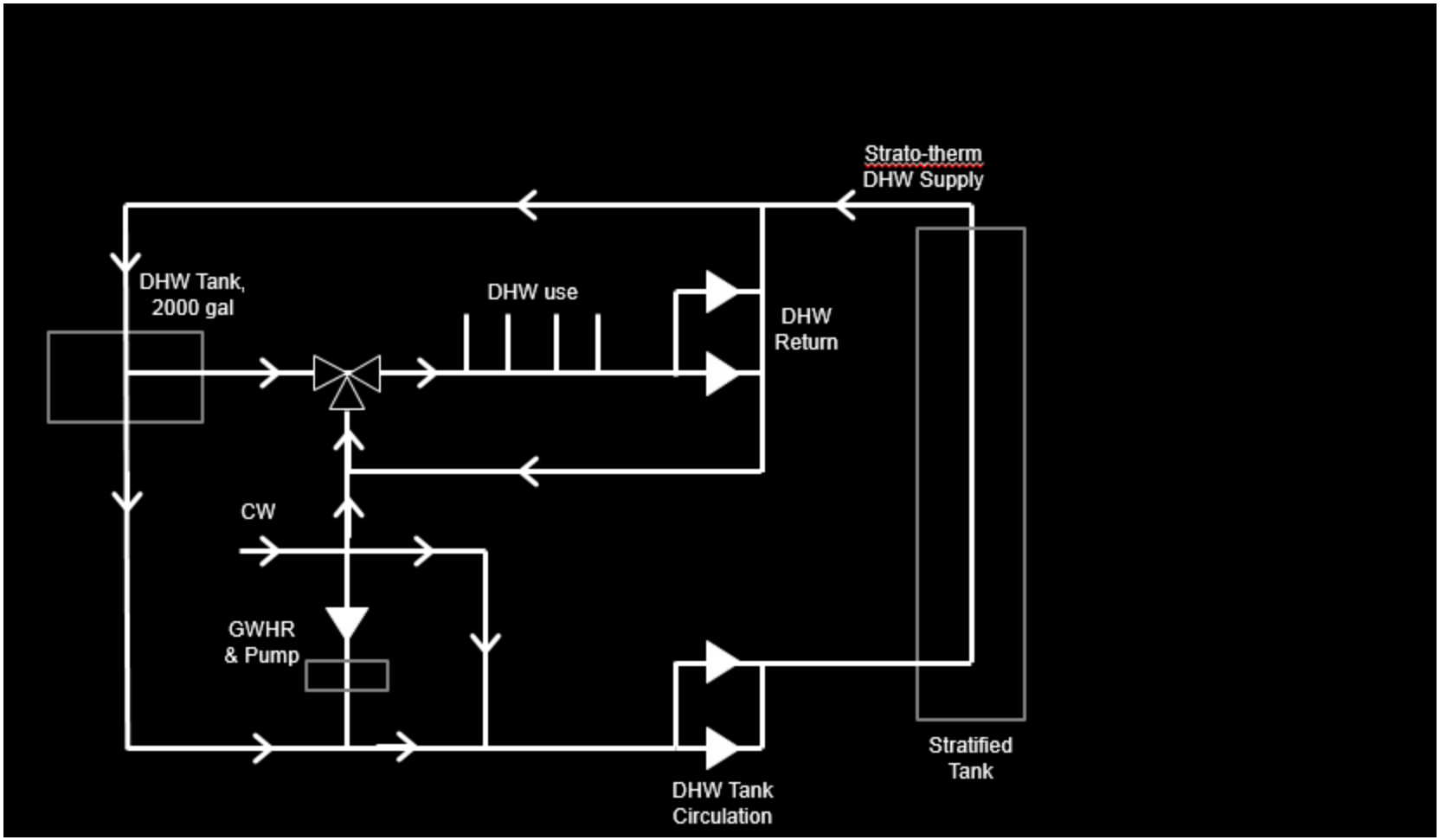
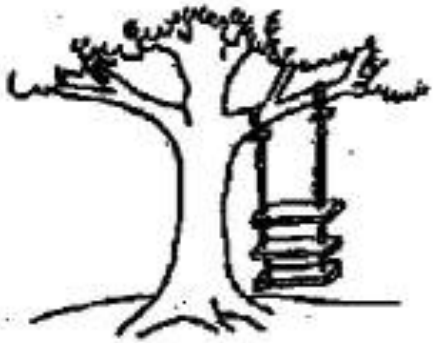
Installed closed-loop hydronic



Installed open-loop system



Quality Assurance covers all project phases



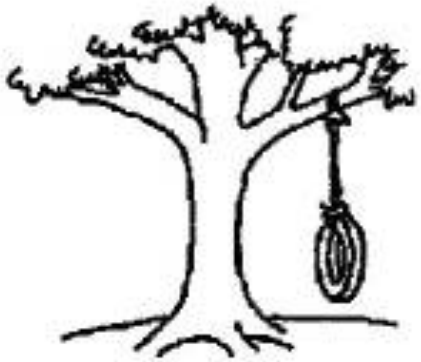
As proposed by the project sponsor.

As specified in the project request.

As designed by the senior analyst

As produced by the programmers.

As installed at the user's site.



What the user wanted.

Energy Modeling (Site Energy)