Air Cooled Condensers

Key Elements for a Successful Specification

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Introduction

- Preparing an ACC specification: How hard can it be?
- All you have to do is prepare a document that will result in an ACC that:
  - Meets applicable codes
  - Has best possible thermal performance
  - Fits in available space
  - Meets all permitting restrictions
  - Has high quality components, materials and workmanship
  - Is easy to erect in the field
  - Includes all the “bells and whistles” desired by operators
  - Lasts for a long time
  - Provides ease of maintenance
  - And so forth . . . . .

Introduction

- **……..All for the lowest cost**

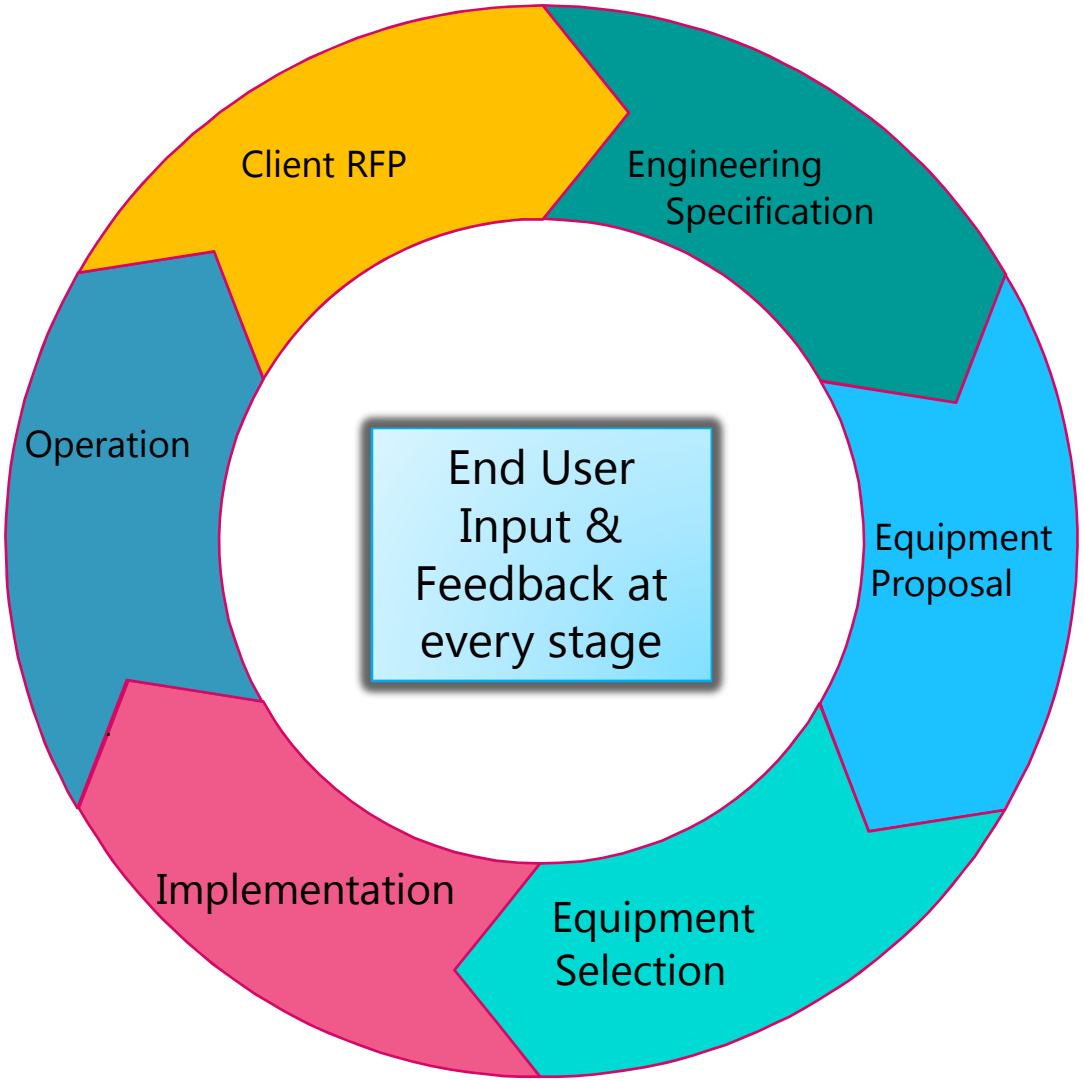
- Becomes a matter of managing the multiple constraints, to balance infinite wants and finite budget
- Requires “homework” prior to spec preparation to go through internal strategies and requirements that can then be put down on paper.
- Cycle chemistry must be part of this homework, and how the ACC fits into the cycle as a whole
- Must consider ACC requirements for current generation of fast start combined cycle plants

Introduction – ACC compared to surface condenser

- ACC specifications (rather than established standards) arguably more important than surface condenser specifications because:
  - Technical scope of ACC is much broader than surface condenser
  - ACC's relatively recent compared to alternatives
  - Industry Standards have not fully caught up with operating experience . (i.e., Surface Condenser HEI Standard is in its 11th edition… ACC HEI Standard in its 1st)

- As a result, more responsibility placed on the engineer and end user to properly specify and establish design criteria

Key for Successful Equipment Specification, Design and Selection



Sources of Input to Specification

- Design engineer knowledge and experience
- Operating experience
- Industry Standards
- Users Groups
- Industry Subject Matter Experts
- Equipment Manufacturers and Suppliers
- Construction and Commissioning Lessons Learned.

Specification Requirements

- At highest level, specification must cover requirements for:
- The **Project** and the **Product**
- Project
  - Communication / Coordination
  - Division of Responsibility
  - Logistics
  - Schedule
  - Shop Inspection and QA
  - Guarantees and field testing
- Product
  - Everything we want the ACC to be when it is complete

Project Scope (DOR)

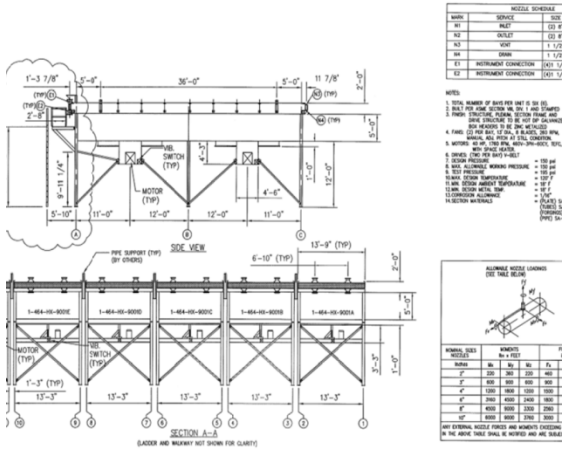
- Division of Responsibilities (DOR)
  - Between ACC supplier and design engineer (supplier vs Balance of Plant scope)
  - Between ACC supplier and installation contractor

Project Scope (DOR)

- ✓ Equipment supply (what the equipment supplier must include vs. what is to be supplied by others)
- ✓ Services Included: Engineering (Design, CFD, shop inspection/testing), Equipment Erection, Technical Advisor (TA) during construction including performance testing and/or operator training
- ✓ Terminal Points – Clear definition, physical location and interface features of steam, condensate, steam-bypass, makeup water, sampling piping including what is to be included (valves) as well as electrical (panels, MCCs) and structural interfaces
- ✓ Additional Systems / Features - Tube Cleaning, Lightning Protection, Freeze Protection, Controls - Some of this may be by balance of plant design engineer
- ✓ Clear definition of shop vs. field fabrication (Understanding of shipping method, routs and limitations)

Project Documentation Requirements

- Establish communication protocol between parties, points of contact, periodic meetings, progress reports, weekly calls, etc.
- Develop drawing and document submittal schedule prioritizing data and information required as input for other activities (GA, foundation design, piping interfaces, electrical loads)
- Establish drawing quality standards and method of presentation (hard copy, pdf, CAD files, 3D model)
- Review and approval cycle



Project Testing and Inspection

- Establish shop inspection requirements including sub-vendors
- Inspection points and witness points
- Code required NDE and Testing (welds, tubes, vessels, piping and valves)
- Drain pumps performance and NPSH testing
- Functional testing of packaged equipment controls
- Equipment TA during commissioning and field testing
- Performance testing protocol (see “Performance Guarantees”)

Specification Requirements for the Project - Summary

- The **Project** requirements . . .
  - Communication / Coordination
  - Division of Responsibility
  - Logistics
  - Schedule
  - Shop Inspection and QA
  - Guarantees and field testing

  . . . . Are critical to getting the best possible **Product**

Specification Requirements - Product

- Two general categories of requirements
  - Requirements to meet applicable codes/standards
    - Typically what the design engineer thinks about
    - Usually non negotiable and straightforward, relatively slow moving requirements
    - Example: Building code
  - Requirements to provide user best value
    - Typically what the user is thinking about
    - Subject to user preferences and available budget
    - Moving target as technology and user experience marches on

Specification Requirements - Product

- Example: Building code
- Necessary for supplier's structural steel design as well as design engineer's foundation design
- Not negotiable, must be followed
- Potential need for third party review (California Chief Building Official is one example)

Elements of a Technical Specification Package

Main Specification

- Scope
- Codes and Standards
- Drawings and Documentation
- Technical Requirements
- Testing and Inspections
- Spare Parts / Special Tools
- Performance Guarantees

Supplemental Specifications

- Electrical Specifications (motors, panels, cables)
- Structural Specifications (steel, platforms, etc.)
- Instrumentation and Controls Specification
- Noise

Project Requirements for the Product

- Site Location - Full meteorological and topographical site data. Wind data for all seasons
- Equipment location – To be optimized based on a number of factors (wind, noise, adjacent structures, space and height limitations)
- Performance requirements – With clear definition of plant operating regime
- Clear division of responsibilities (DOR) for all associated equipment and services

Performance Requirements

- ✓ All applicable data from ST heat and material balance for all operating cases, and ambient conditions (guarantee, summer peak, winter, part load, start up, steam turbine bypass, etc.)
- ✓ Wind speed and direction criteria for all seasons and basis for guarantee point
- ✓ Clear definition of performance expectations including terminal point and plant utilities conditions (pressure, temperature, enthalpy, O2 limits, electrical sources, etc.)
- ✓ Noise limits and criteria – Existing noise environment at the site and vicinity, applicable Laws, Ordinances, Regulations, and Standards (LORS) and noise limits (both during construction and operation) that must not be exceeded
- ✓ Water quality and other chemistry issues (must reflect an operations strategy to be put in place)
- ✓ Methods for performance measurements

Performance Requirements

- ✓ Water quality and other chemistry issues:
  - ✓ Part of the upfront “homework” is a strategy for cycle chemistry
  - ✓ IAPWS Technical Guidance Documents on cycle chemistry provide background and recommendations, including topics specific to ACC’s, as an aid to establishing a strategy for project specific chemistry
  - ✓ ACC spec must support and be consistent with chemistry strategy

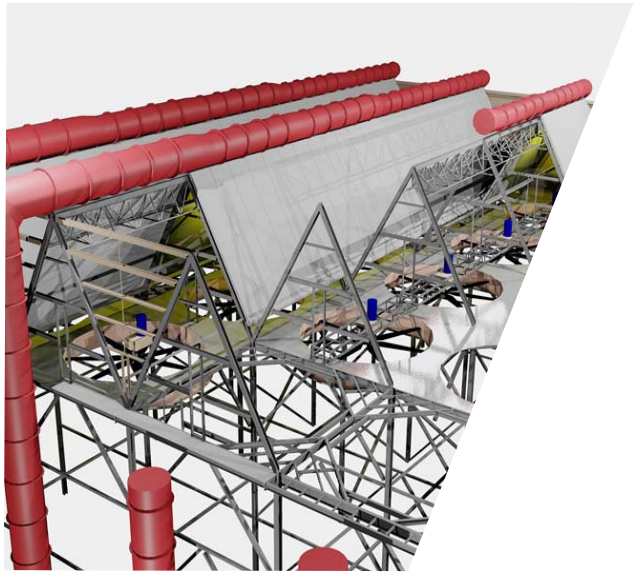
Codes and Standards (partial list)

- HEI 3087 Air Cooled Condensers
- ASME B&PVC Section VIII Pressure Vessels
- ASME B31.1 Power Piping
- ASME PTC 30.1 (Test Code) for Air-Cooled Steam Condensers
- NEMA MG-1 Motor and Generator Standards.
- AGMA –American Gear Manufacturers Association
- ABMA –American Bearing Manufactures Association
- AISC – American Institute of Steel Construction

Codes and Standards (Partial List)

- AWS –American Welding Society
- CFR – Code of Federal Regulations – OSHA
- EJMA – Expansion Joint Manufacturers Association
- FAA – Federal Aviation Administration
- FM – Factory Mutual
- IEEE _ Institute of Electrical and Electronic Engineers
- ISA – Instrumentation, Systems and Automation Society.
- IBC – International Building Code
- ISO – International Organization for Standardization
- ICEA -Insulated Cable Engineers Association
- NACE National Association of Corrosion Engineering.
- NEC -National Electric Code
- State and Local Codes and Regulations

Technical Requirements



General Requirements

- Materials requirements (Pressure part ASTM specifications, piping, valves corrosion allowances, FAC concerns)
- Approved manufacturers of sub-components (motors, gear boxes, pumps, valves, instrumentation)
- Maintenance access

Technical Requirements

ACC Design Requirements

- Type of construction (tube and fin material, fin spacing, and fin length)
- Steam duct, ST expansion joint, loads and moments
- Steam duct drains, drain pots, drain pumps
- Steam bypass – number of connections, conditions
- Need for modeling and CFD analysis for all known wind conditions to optimize design and avoid cell stall, recirculation
- Provisions for cold weather operation (means to isolate individual headers/sections, freeze protection)
- Spray curtains and miscellaneous connections for condensate return
- Tube water spray washing system

Technical Requirements

ACC Structural Requirements

- Establish criteria and applicable LORS for snow, wind and seismic design
- Establish structural safety factors and local Building Official (CBO) submittal requirements
- Establish criteria for location and loading of access stairs, platforms and walkways
- Establish criteria for fan vibration prevention, structural resonance

Air Removal Equipment

- Vacuum pumps vs steam driven equipment
- If steam driven, Steam Jet Air Ejector (SJAE) criteria, hogging, holding
- Inter/after condenser
- Specify motive steam conditions and Inter/After condenser cooling method
- Air leakage meter

Technical Requirements

Fans, Gear and Drives

- Single speed, dual speed or VFD
- Fan blade arrangement, material, balancing requirements and method of attachment
- Fan motor specification and size limit
- Gear design, service factor and bearing life
- Motor location, Fan Guards, vibration switches and lubrication

Technical Requirements

Wind Walls and Screens

- Wind Walls (Siding) material, color and height (from fan deck to top distribution duct)
- Wind Screens as required to minimize effects of crosswinds

Technical Requirements

Vacuum Deaerator / Condensate Receiver

- Deaerator integral with receiver
- Deaerator performance requirements (7 ppb dissolved O2) for the specified range of loads
- Deaerator operating pressure and makeup water flow
- Condensate storage (volume) requirements, temperature and level instrumentation and sparging for low load conditions
- Condensate storage and Deaerator materials of construction and corrosion allowance

Technical Requirements

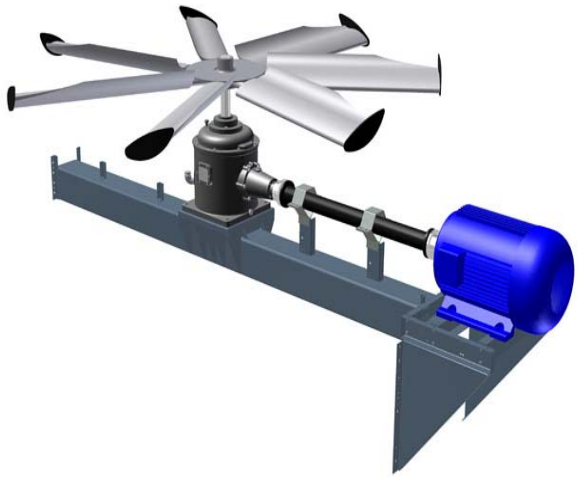
Welding Requirements

- Shop WPS and PQRs – Welder qualifications.
- Preparation of pipe ends for field welding

Electrical, Instrumentation and Controls

- Electrical Specification (Motor, enclosures, MCCs, cable and conduit if applicable)
- Instruments to be included (from list of approved vendors) or provisions/connections only (to be supplied by others) for commonality with the rest of the plant
- Control philosophy / control logic narratives
- DCS interface and safety features

Spare Parts and Special Tools



- Commissioning Spare Parts
  - ✓ Gaskets, Seals, Consumables
- Long Term Spare Parts
  - ✓ Spare Motor
  - ✓ Spare Gear Box
  - ✓ Bearings, Fan Blades, Couplings
  - ✓ Vibration Switches
- Special Tools
  - ✓ Blade alignment tool

Performance Guarantees and Testing

- Clear understanding and agreement of what is being guaranteed (condenser duty, backpressure, O_2, power consumption, noise, recirculation, etc.) and the conditions for the guarantees (load, ambient temperature, wind speed, water chemistry)
- Agreement on performance measuring methods and standards (ASME PTC 30.1), instrument calibration, test measurement uncertainty and commercial tolerance
- Detailed performance test procedure to be prepared later
- Commercial Issues: Remedies, Tradeoffs (if any) and Liquidated Damages

Current Topics as Product Requirements

- Topics driven by lessons learned and discussions from ACC users
- Heavily influenced by project specifics including economics
- Topics include:
  - Motors / VFD's
  - Wind screens
  - Tube and fin materials
  - Fan and bridge dynamics

Current Topics: Motor Selection

- Options are:
  - Single speed
  - Dual speed
  - Variable Frequency Drive (VFD)

Single speed – lowest cost, total ACC air flow adjustment steps by single cells on or off

Two speed – twice as many steps for air flow adjustment, additional motor and cabling cost

VFD – Infinite performance steps, cost of VFD.

- Auxiliary power benefit

Classic economic cost / benefit to choose what is best for a given project

Current Topics: Wind Screens

- Still a developing science
- Trade offs: Additional power needed to drive air flow when wind speed is low, but improved air flow management when wind speed is higher.
- Clearly value in high wind conditions, but must be designed correctly
- Site specific CFD modeling is requirement
  - At what stage of project? How to equalize the playing field to bidders?
- Potential for adjustable wind screens
  - Minimize airflow losses when not needed, moved into place when windy conditions dictate

Current Topics: Fan and Bridge Vibration

- Topic is understood – Induced vibrations in the fan bridge structure from fan and wind dynamics during rotation
- Relationship between fan speed and structure frequency must be understood in order to avoid critical frequencies
- Supplier must accomplish through design and some field checks, with possible modifications needed in field

Current Topics: Tube and Fin Materials

- Most Common tube material is carbon steel covered with aluminum
- Other materials possible
- For common carbon steel plus aluminum design, cladded (cold process) vs coated (hot process)
- If cladded is desired must be specifically stated

Summary and Takeaways

- Project Requirements and Product Requirements, specification must cover both
- Communication and Feedback from Clients, Operators, Equipment Manufacturers and Industry experts are key elements for success.
- Do your “homework” ahead of time for project specific requirements and user preferences
- Proper scoping ensures no items are left behind.
- Mutual understanding and agreement of scope, performance, deliverables, guarantees, acceptance criteria, tradeoffs and liquidated damages from the start prevent future problems.
- Lessons learned prevents duplication of errors.

Thank You

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