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# Liquid Cooling Facility Hook-up Standards

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# Outline

- ASHRAE Liquid Cooling Guidelines
- Schedule & cost concerns in liquid cooling facility/ platform integration
- Decoupling facility/platform schedules through mechanical connection standards
- Views and discussion
  - Josip Loncaric, LANL
  - Anna Maria Bailey, LLNL
  - Dave Martinez, SNL

# ASHRAE Liquid Cooling Guidelines

- EE HPC Working Group helped develop ASHRAE Liquid Cooling Guidelines in 2011
- Water temperature ranges W1 through W5
  - Discussion of typical ΔT (5°C to 10°C), flow rates
- Basic water chemistry & wetted materials described
- Pressures <690 kPA (100 psi), ΔP > 0.4 bar (5.8 psi)
- Vague on facility/platform integration details

| | Typical Infrastructure Design | | |
|---|---|---|---|
| **Liquid Cooling Classes** | **Main Cooling Equipment** | **Supplemental Cooling Equipment** | **Facility Supply Water Temp(C)** |
| W1(see Figure 3a) | Chiller/Cooling Tower | Water-side Economizer (w drycooler or cooling tower) | 2 - 17 |
| W2(see Figure 3a) | | | 2 - 27 |
| W3(see Figure 3a) | Cooling Tower | Chiller | 2 - 32 |
| W4(see Figure 3b) | Water-side Economizer (w drycooler or cooling tower) | N/A | 2 - 45 |
| W5(see Figure 3c) See Operational Characteristics | Building Heating System | Cooling Tower | >45 |

| Parameter | Recommended Limits |
|---|---|
| pH | 7 to 9 |
| Corrosion Inhibitor(s) | Required |
| Sulfides | <10 ppm |
| Sulfate | <100 ppm |
| Chloride | <50 ppm |
| Bacteria | < 1000 CFUs / ml |
| Total Hardness (as CaCO3) | <200 ppm |
| Residue After Evaporation | <500 ppm |
| Turbidity | <20 NTU (Nephelometric) |

# Schedule & Cost Concerns in Liquid Cooling Facility/Platform Integration

- It takes 2-5 years and $10+ M to plan, design, build, and commission liquid cooling for a major facility
- Industrial scale engineering, 36” water pipes, lots of engineering requirements (e.g. ASME B31.9 pressure compliance, water treatment, controls, etc.)
- When done, it’s not *really* done
  - Branch piping must be designed for the platform
  - But the platform isn’t known far in advance (must wait for the platform contract to be sure)
  - Another $M+ site prep project of 6-8 months
  - This works for major platforms, almost, at a cost
  - This isn’t suitable for quick commodity deployments

# LANL Liquid Cooling - Mechanical

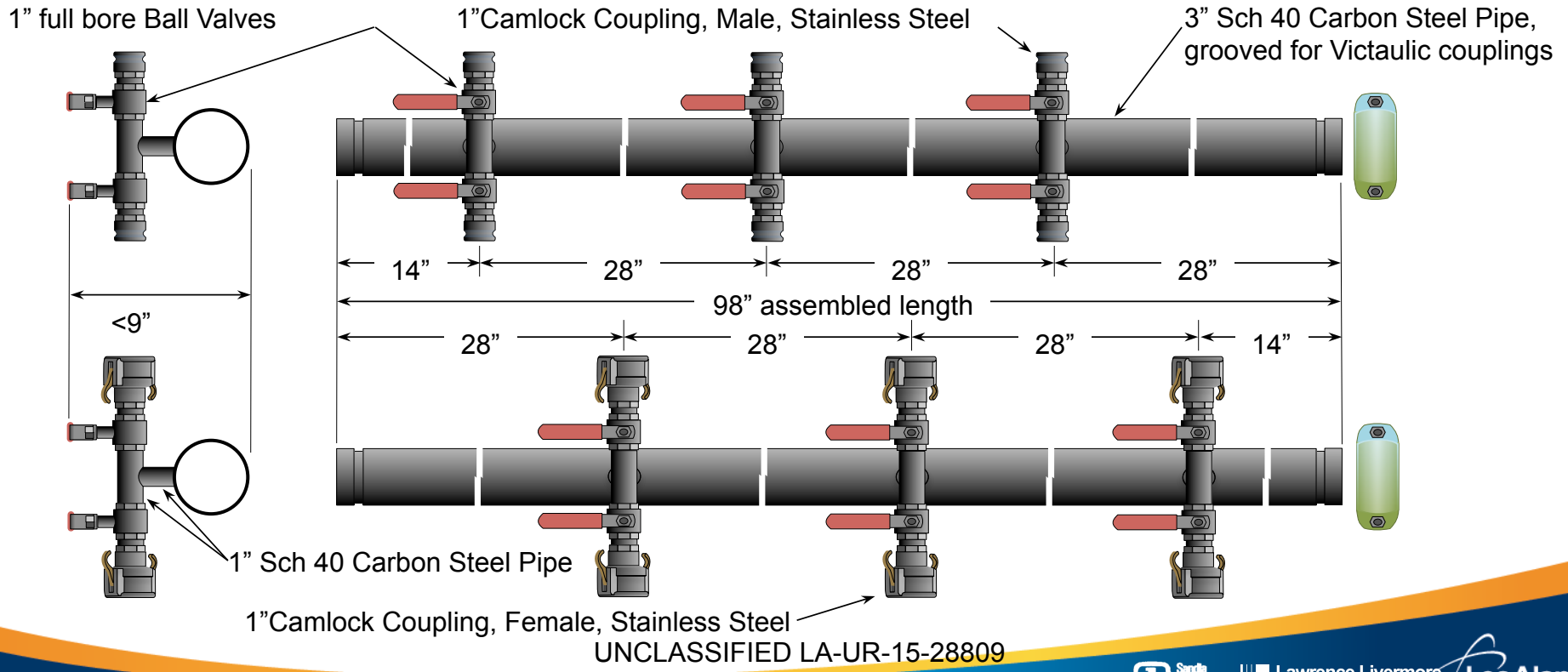

- Cooling Towers
- Heat Exchangers
- Tower and Process Pumps
- Strainers and Tanks
- Air Handling Units

# LANL Trinity Phase 1 Platform

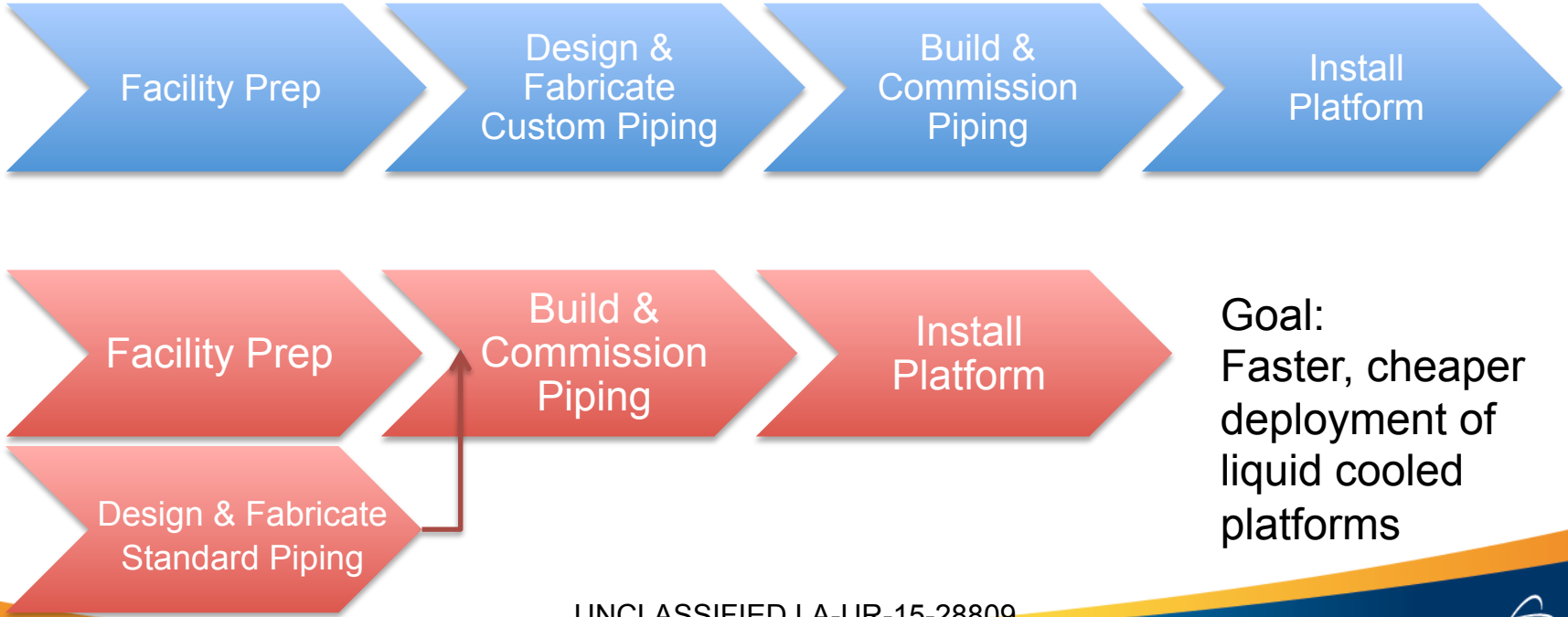
# Liquid Cooling for Commodity Technology Systems

- Tri-lab CTS-1 contract with Penguin Computing
  - http://www.nnsa.energy.gov/mediaroom/pressreleases/nnsa-announces-procurement-penguin-computing-clusters-support-stockpile
  - Liquid cooling option supplied by Asetek
- *Enabling Rapid Site Preparation for Liquid Cooling*
  - Option for pre-fabricated under-floor liquid cooling piping segments
  - Goals yet to be proven:
    - Faster: Moves piping design, fabrication, certification off the critical path
    - Cheaper: Standard vs. custom parts

# Dual Row CTS-1 Manifold Pair



# Decoupling Facility/Platform Schedules Through Hook-Up Standards




Goal:
Faster, cheaper deployment of liquid cooled platforms

# Define Interfaces, Decouple Facility from Platform Design

- Pipe diameters
  - Connection points
  - Standardization is the goal
- Coolant chemistry / pipe materials
  - Start: ASHRAE guidelines
  - Basic chemistry (rust inhibitor, biocide)
  - Spill containment
- Pressures supply / return
  - Pressure differential
- Controls
  - Division of control authority between facility / multiple platforms
  - Or work toward a single interface
- Data center layout / modular design / zoning
  - Adopt proven techniques from the old liquid cooled platforms
  - Modernize to achieve extreme scale
- Safety
  - Leaks
  - Fire suppression
  - Interfacing on or near electrical / leak detection

# Discussion & Views

# Josip Loncaric, LANL

- Facility pipes are large and stay with the facility: 18”, 24”, 36”, …
- Branch pipes are smaller, come and go with platforms: 8”, 6”, 4”, 3”, 2”
- Examples:
  - 20 MW platform in ~200 racks
    - 14 branch pipes to cool ~1.4 MW each
    - At 5°C ΔT and 1200 gpm, 8” pipe cools up to 1.6 MW
  - 50 kW platform in 2 racks
    - Single 2” branch pipe suffices at 5°C ΔT and 40 gpm
  - Steps of 2x from 50 kW to 1600 kW seem reasonable
    - 50 kW, 100 kW, 200 kW, 400 kW, 800 kW, 1600 kW per branch
  - Facility design to support a suitable branch pipe size, with headers at strategic locations, e.g.
    - Large facilities, multi-MW platforms: 8” branch pipe headers
    - Medium facilities: 4-6”
    - Smaller facilities: 2-3”
- Simple control strategy: Facility controls supply pressure, platforms control flow rates (within constraints)
- Platform procurements specify platform-independent facility capabilities
  - Branch piping delivered and removed with the platform
  - Most of branch piping design is moved off the critical path, with less custom fabrication, easier pre-ship testing

# Anna Maria Bailey, LLNL

- Facility design should focus on modularity and scalability in liquid cooling standardization in right sizing of solutions
  - Pumping systems
    - Pump sizes
  - Piping systems
    - Material selection is key
  - Heat exchangers
  - VFDs
  - Controls
  - Monitoring
  - Metering
  - Chemical treatment

# Dave Martinez, SNL

- Facility pumps/pipes main braches remain intact
- Primary cooling/control system remains intact on the primary side
  - Based on past performance
    - kW per ton
    - Water evaporation (blowdown, water evaporation, chemicals)
    - Overall performance (energy efficiencies / required maintenance )
    - New Technologies
- Secondary side should be flexible to a point
  - Should remain :
    - Main valves
    - Pumps/VFD’s
    - Large heat exchange systems (not CDU’s)
    - Controls/sequence

# Abstract


- Interfacing facilities to liquid cooled HPC platforms presents schedule and cost challenges, particularly for commodity technology systems where rapid low cost deployments are sought. Hook-up standards may reduce barriers to wider adoption of liquid cooling.