ACF - Advanced Cooling Facilities

A Sub-Project of OCP Cooling Environments Project

Connect. Collaborate. Accelerate.

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Our Mission

- Develop
  - Best practices
  - Collaboration documents
  - Common guidelines
- Facilitate integration of Advanced Cooling Solutions (ACS) into Data Center Facilities(DCF)
- Develop standardized practices in connection of vendor-based ACS solutions to Facility Water Systems (FWS) and/or Condenser Water Systems (CWS)
- Maximize, at lower cost and minimal operational impact.
  - Scalability
  - Efficiency
  - reliability

GUIDELINES FOR CONNECTION OF LIQUID COOLED ITE TO DATA CENTER FACILITY SYSTEMS

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Project	Cooling Environments > Advanced Cooling Facilities
Accept Year	2022

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Guidelines for Connection of Liquid Cooled ITE to Data Center Facility Systems

Revision 0.1

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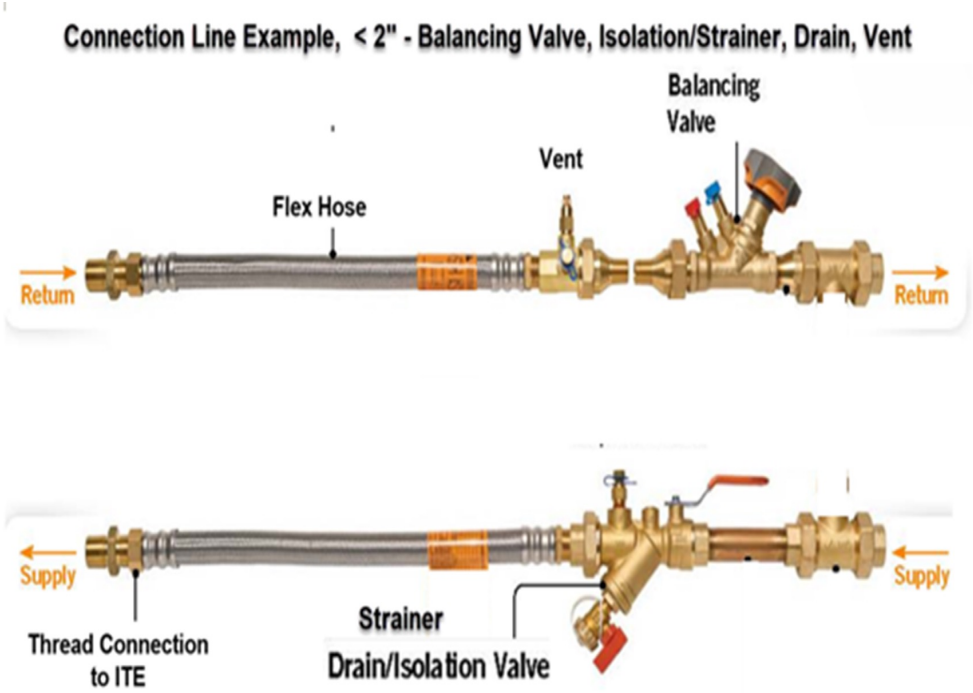
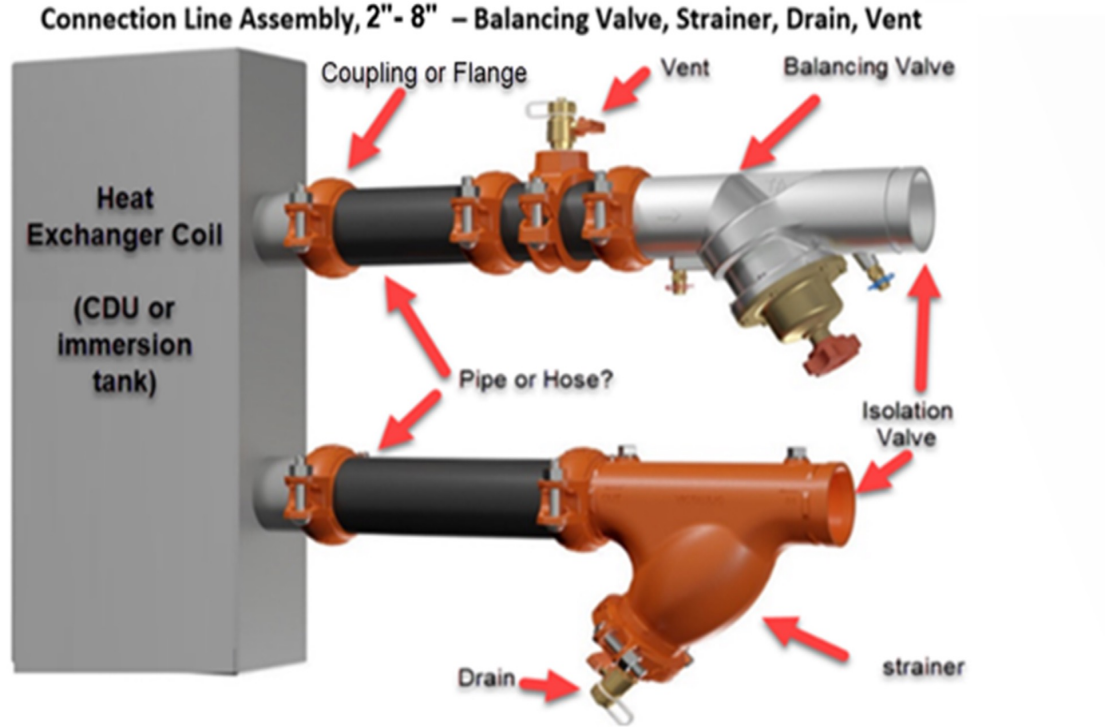
Connection Line Functions





- **Vent, drain ports** – Simplify exchange/maintenance of ITE and CDU. Drain ports are often incorporated with the strainer
- **Strainers** - prevent contamination of heat exchanger coils.
- **Flushing**– During initial commissioning and major system updates, pipe systems should be flushed - requires flush connections.
- **Metering points** – pressure/temp ports for dP and flow measurement. Many ITE and CDU solutions have ports included.

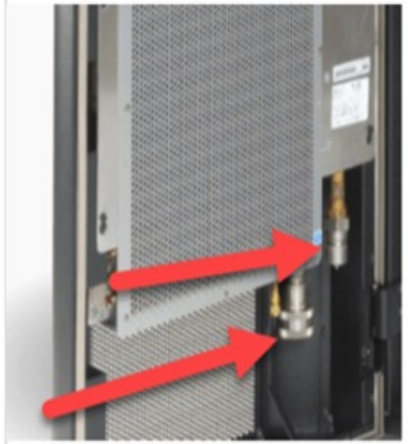
Leak Protection – Cost Vs Risk

Ability to Prevent Leakage by Installation Inspection

	Inspection Method to Prevent		MTBF Data	Leakage/Failure Protection Recommendation
	Leakage	Failure		
ReConnection Methods				
Threaded	None	Visual	N/A	**leakage detection and protection recommended -** failure unlikely
Flange	Torque check	Torque check	N/A	**Leak detection/protection recommended.** Re-torque verification over life of pipe of critical joints
Grooved Coupling*	Visual	Visual	>185 million hours	Auditable record of proper installation inspection required to avoid additional protection.
Fixed Connection Methods				
Weld	X-Ray	X-Ray	N/A	Record of Radiography to avoid additional protection
Crimped/pressed	???	???	N/A	**Leak detection & failure protection recommended** Visual inspection may provide some validation
Fused	???	???	N/A	**Leak detection & failure protection recommended**
Pressure test is always a requirement				
***Grooved Coupling performance based on mission critical standards of design, quality control, certified inspection process**				
Pipe movement (thermal, vibration, building, seismic) can create leakage and possible separation in pipe systems if not addressed				

Standardizing ITE to FWS <1.25”/DN40

Rack and Door Pipe Connection Thread Standards - BSPP, Female	
1"/DN25	1.25"/DN40



Thread Connection Standardization Benefits:

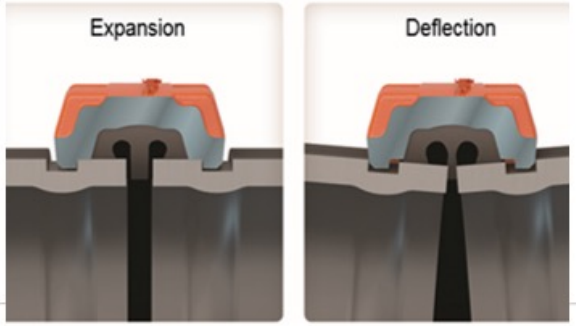
- **Vendors currently standardize** on single thread type, ship adaptors as needed
- **Thread verification** is a key issue
- **Metric thread** is global and growing.
- Different thread types have **different installation methods**
- **Quick disconnects** attach via thread

Thread Installation, BSPP

- O Ring – replace each connection
- Thread tape –
  - clean threads, apply tape with each installation.
  - Ensure tape does not protrude into water flow
- Inspect for leakage on pressure test & 4 hours later

Standardizing ITE to FWS >2”, DN50

Connections: 2"/DN50 to 8"/DN200 Class 150 Flanges Vs Mission Critical Grooved Couplings		
	Class 150 Flange	**Mission Critical Coupling**
Bolt Count	**4 to 8 bolts**	**2 bolts**
Alignment adjustment	**none**	**Multi axis alignment**
Movement	None, requires torque verification	design feature
Vibration Mitigation	None	design feature
Inspection method to prevent leakage	torque + pressure test; re-torque as needed	Visual inspection + pressure test = certified for life of pipe system
MTBF	N/A	>185 million hours



Pipe Connection Size Estimating

- Connection size is a key parameter setting the KW capacity of future liquid cooled ITE.
- The Table illustrates the trade-offs between flow velocity, diameter and delta T.
- This type of quick estimation can give a facility owner a quick idea of the maximum cooling they might get if they have available pipe taps.

Constant Flow				Delta T							
Pipe Size		ASHRAE 90.1-2019		4	6	8	10	12	14	16	C
				7.2	10.8	14.4	18	21.6	25.2	28.8	F
DIN	in	l/s	GPM	Max kW							
50	2	2.97	47	50	75	99	124	149	174	199	
65	2-1/2	4.29	68	72	108	144	180	215	251	287	
80	3	6.94	110	116	174	232	290	348	407	465	
100	4	13.25	210	222	333	444	554	665	776	887	
150	6	27.76	440	465	697	929	1162	1394	1626	1859	

Maximum practical cooling, pipe size vs. fluid temperature rise

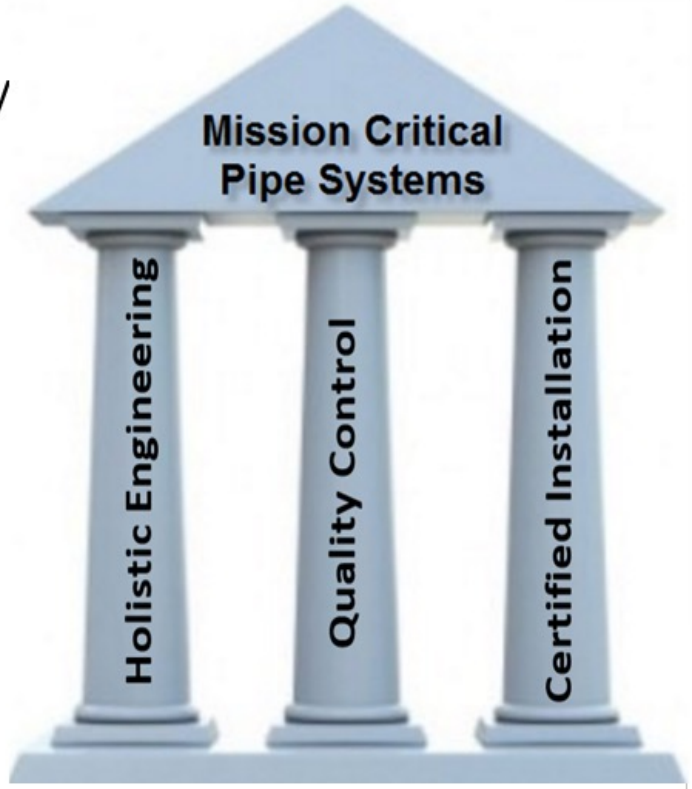
Mission Critical Systems: Apply SUBSAFE to Data Centers

Design - Holistic solution, to include temperatures, pressures Flexibility and movement.

Quality Control - Traceable to date, location of manufacture and associated quality tests

Certified Installation – leak-proof, maintenance free for life of facility based on auditable verification of proper installation + pressure test.

If proper installation is not verified, reliability is undefined

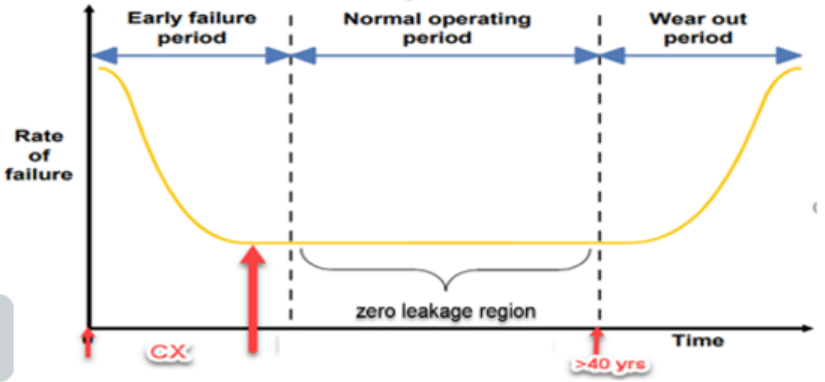


Verification of Installation Allows use of Reliability Science

Reliability Study Chart, Mission Critical Rated Coupling Solutions[1]

Connection Type	Failure Rate (per 10^6 Hours)	MTBF (Hours)
Mission critical rated Grooved Coupling/Fitting	0.00537726	185,968,230

https://www.alionscience.com/labs-and-facilities/



The **Alion System Reliability Center** is comprised of the employees that operated the **Reliability Analysis Center (RAC)**, which is the Department of Defense's (DoD) recognized center of reliability excellence. The RAC was operated by Alion/IITRI from 1968 through 2005.

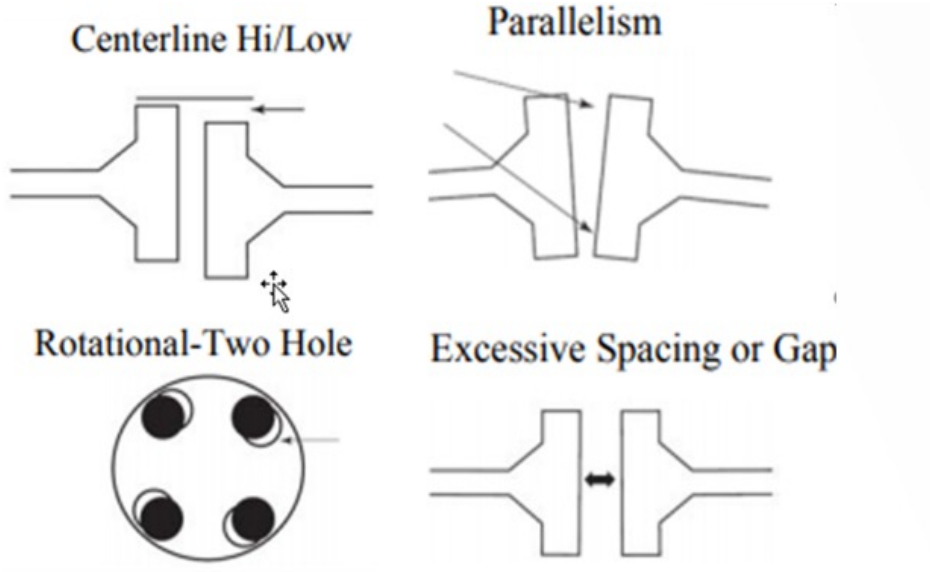
The Alion System Reliability Center (SRC), under a contract with [redacted] was requested to independently quantify the reliability, availability, and maintainability (RAM) of their Grooved Coupling System intended for use on mechanical systems, such as chilled, condenser, hot & potable water.
The [redacted] Grooved Coupling System offers an alternative to traditional connections (i.e. weld, flanged, threaded) when joining pipes with much less labor required and still maintaining a 50-year expected life. The Grooved Coupling System uses a precast housing that is secured over the ends of two grooved pipes. A gasket provides a leak tight seal between the grooved coupling and the piping. For chilled, hot, condenser and potable water applications, the gasket material is an Ethylene Propylene Diene Monomer (EPDM) Grade "E" material.

… From this data, it is evident that the [redacted] Grooved Coupling/Fitting System will meet and exceed the availability requirements of mechanical systems for an **expected life of 50 years.**

Reliability Vs Movement, Alignment

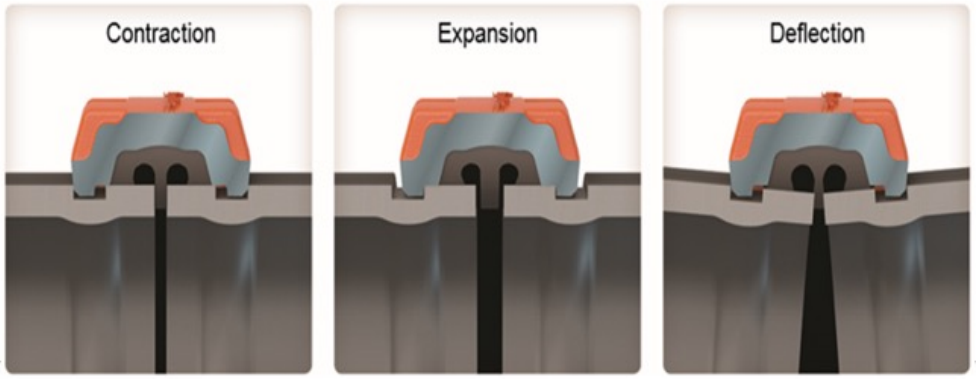
Flange Solutions:

- Centerline, Parallelism, Rotational mis-alignment creates pipe stress
- Pipe movement & vibration issues require other devices
- Torque verification after pipe movement events



Flexible Coupling

- Rotation, expansion, contraction, deflection addressed by design
- Vibration Mitigation
- 25+ years, no maintenance



Fused Connection Verification

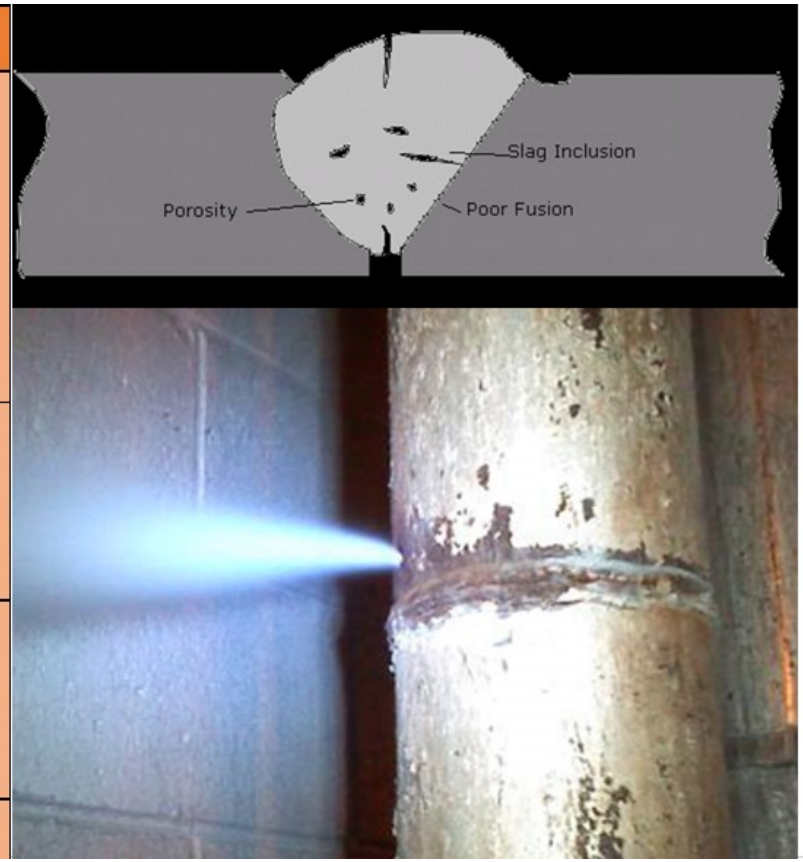
Variables to Control	Potential Issue	Detection Method
Depth of fusion section	Is pipe fully inserted into connection?	To be used in areas of elevated severity risk, fused connections should provide method to verify proper installation.
Transition Time	Connection cool down can result in incomplete insertion	
Temperature, jobsite	Affects cool down rate, heating time	
Not using enough heat	If heat time is insufficient, will not make full connection	
Cleanliness of Pipe	Incomplete fusion area (oil, dirt)	
Water contact	Any water contact on fusion area will interfere with proper fusion	
Support during Cool Down	Movement during cooling weakens bond	
Adjustment during cooldown	Twisting, adjusting alignment after 5 seconds weakens connection	
Mis-alignment	> 3 degrees of mis-alignment may affect bond	Alignment verification

Fusion Processes are dependent on skills of installer.

In severe risk applications, method of detection of proper installation is strongly recommended

Performance of Welds Depends on Welder and/or Radiography

Weld Challenges
Joint quality - - internal cracking - porosity - bubble pockets - lack of fusion
Pipe interior - slag build-up - Flow variation - water contamination
Heat Affected Zone - - accelerated corrosion near weld
Distortion, alignment stress



Radiography recommended for high severity risk locations

Weld Failure modes include:

Separation

- poor / incomplete fusion
- Cracks

Typically discovered at pressure test

Accelerated corrosion

- porosities
- Regions near weld **(HAZ)**

Leaks 3-10 years after installation

OPEN Compute Project

- Call to Action:
- Get in Involved!

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- OpenCompute Cooling Environments Project
  https://www.opencompute.org/projects/cooling-environments
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