Modular Data Centers

Henry Coles, Program Manager, M.S.
Lawrence Berkeley National Laboratory
hccoles@lbl.gov

Presentation

Modular Data Centers

- Introduction
- Survey
- Comparison: Modular to Brick and Mortar
- Efficiency Evaluation
- Evaluation Results
- Conclusions

Corrosivity Study – Outside Air for Cooling

- Introduction
- Corrosion Example
- Method Used
- Survey Results
- Conclusions

Introduction: Modular Data Centers

Definition: ISO “shipping” container and other transportable component form factors, final or pre-assembly and configuration at manufacturer

History: prominent in 2007 (Sun Black Box), now offered by many suppliers

Design: variety of size, layout, IT density, cooling and electric power distribution options

Cooling Design Options:

- free air cooling (a.k.a. air-side economizer)
- free air cooling with adiabatic assistance (evaporation)
- free air cooling with DX
- cooling tower and/or chilled water with fans
- cooling tower and/or chilled water without fans

Sample of Modular Data Center Companies

- Hewlett-Packard: POD and EcoPOD
- i/o : i/o.ANYWHERE
- SGI: ICE Cube, ICE Cube Air Modular Data Center
- Pacific Voice & Data: MCIE (Modular Critical Infrastructure Enclosure) Solutions and Disaster Recovery Mobile Data Centers
- Elliptical Mobile Solutions: MMDC (Micro Modular Data Center)
- Liebert: MDC20-XDR-53
- IBM: PMDC (Portable Modular Data Center)
- PDI: i-Con
- Cirrascale: FOREST Containerized Data Center (formally Verari FOREST)
- Dell: MDC
- Lee Technologies: ITModules
- Telenetix: T-Cube
- Universal Networking Services: Datapod Containerized System
- NxGen Modular: NxGEN600
- BladeRoom Group Ltd: Blade Room system
- Bull: Mobull

Modular Data Centers

Survey

io.Anywhere®

Cooling:
- free air option
- chilled water

Hewlett Packard
HP POD

Cooling:
- chilled water

Ice Cube Air
Modular Data Center

Cooling:
- air-side economizer cooling

Hewlett Packard – EcoPod™

Cooling Modes:

1 -Air-Side Economizer Standard
Free air cooling when outside 58-87°F(14.4-30.5°C)

2- DX (direct expansion) assist when needed

Hewlett Packard – EcoPod™

Air-Side Economizer Mode “free cooling”

~~Chilled Water~~
And
Some Electricity
Required

Exhaust Air

~~¥¥¥¥~~
Ambient Air

~~¥¥¥¥~~
Ambient Air

IT Equipment

Comparison Brick and Mortar to Modular

Primary Attributes	Traditional "Brick and Mortar" Data Center	Modular Data Center
Time to Deployment	Long – typically two years from design to commissioning	Potentially short – perhaps in months depending on site conditions and available infrastructure
Capital Cost	Highest – generally thought to range 10- $20 million (¥837,222,000 - ¥1,674,444,000) per 1 million watts of IT capacity	Lower – though there is a lack of documented deployment costs
Operating Cost	Variable, with legacy data centers having PUE's exceeding 2.0 and best-in-class designs approaching 1.2 or lower if using outside air for cooling	Similar to traditional data center using the same cooling type. Pre-engineering and better system integration may provide some advantages.

Energy Efficiency Evaluation
6 Companies Involved

- Hewlett Packard
  - HP POD (2 cases)
  - HP EcoPOD (1 case)
- io Data Centers
  - i.Anywhere (4 cases)
- Liebert
  - (6 cases)
- SGI
  - (2 cases)
- PV&D (Pacific Voice & Data)
  - (4 cases)
- EMS (Elliptical Modular Solutions)
  - (4 cases)

Details: http://hightech.lbl.gov/documents/data_centers/modular-dc-procurement-guide.pdf

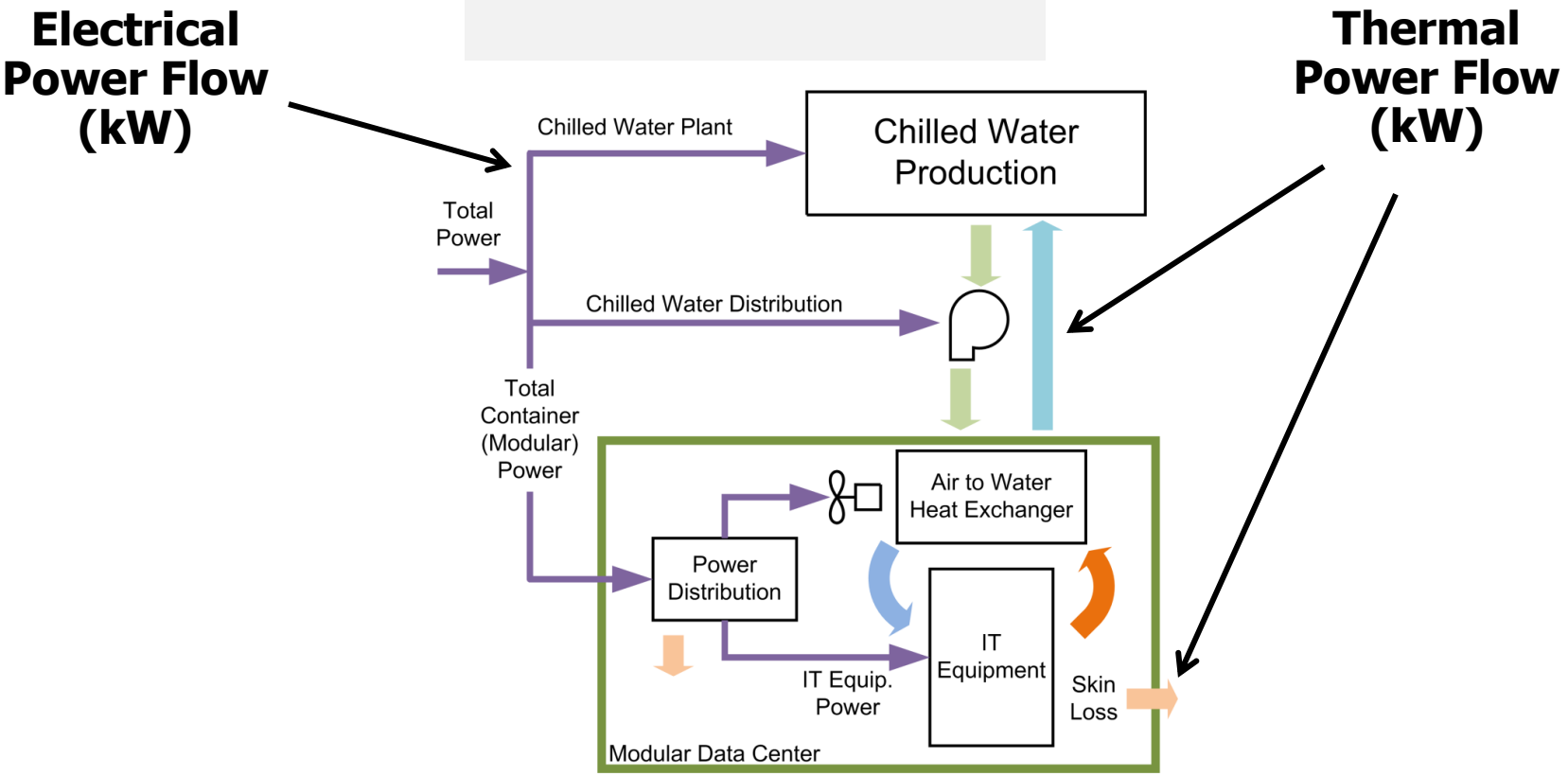
Evaluation Case Data

Data Provided by Company Listed								
Company	Cooling Type Server Air Inlet Temp.(F) Chilled Water Supply Temp.(F) Server Air Flow (cfm/kW)	IT Power [ITPp] (kW)	Distribution and Transformer Loss [DTLp] (kW)	Skin Loss [SKNp] (kW)	Chilled Water Flow [CWFp] (gpm)	Chilled Water Delta Pressure [CWDPp] (ft. WC)	Chilled Water Plant Performance [CWPRp] (kW/ton)	DX Cooling [DXPp] (kW)
HP	Water-WC, 72, 62, 112	580	5.8	10	240	75	0.265	NA
HP	Water-WC, 80, 70, 91	580	5.8	10	240	75	0.158	NA
HP	Outside Air, 72, NA, 112	1520	15.2	NA	NA	NA	NA	NA
i/o Data Centers	Water-WC, 80, 60, 120	200	8.0	0	126	18	0.294	NA
i/o Data Centers	Water-WC, 80, 60, 120	1000	41.0	0	630	22	0.294	NA
i/o Data Centers	Water-WC, 80, 60, 120	3200	132.0	0	2016	27	0.294	NA
i/o Data Centers	Water-WC, 80, 60, 120	6400	265.0	0	4032	34	0.294	NA
Liebert	Water-WC/DX, 75, 55, 120	300	15.0	0	280	39	0.370	NA
Liebert	Water-AC/DX, 75, 55, 120	300	15.0	0	280	39	*0.980*	NA
Liebert	DX, 75, NA, 120	200	10.0	0	NA	NA	NA	72.0
Liebert	Water-WC/DX, 80, 60, 120	300	15.0	0	280	39	0.294	NA
Liebert	Water-AC/DX, 80, 60, 120	300	15.0	0	280	39	*0.900*	NA

Evaluation Case Data (continued)

Data Provided by Company Listed								
Company	**Cooling Type Server Air Inlet Temp.(F) Chilled Water Supply Temp.(F) Server Air Flow (cfm/kW)**	**IT Power [ITPp] (kW)**	**Distribution and Transformer Loss [DTLp] (kW)**	**Skin Loss [SKNp] (kW)**	**Chilled Water Flow [CWFp] (gpm)**	**Chilled Water Delta Pressure [CWDPp] (ft. WC)**	**Chilled Water Plant Performance [CWPRp] (kW/ton)**	**DX Cooling [DXPp] (kW)**
Liebert	DX, 80, NA, 120	200	10.0	0	NA	NA	NA	66.9
SGI	Outside Air, 77, NA, 120	280	2.8	NA	NA	NA	NA	NA
SGI	Water-WC, 77, 65, 120	750	7.5	0	525	15	0.223	0
PVD	Water-WC, 72, 58, 100	400	0.0	0	300	45	0.324	NA
PVD	Water-WC, 80, 68, 100	400	0.0	0	300	45	0.184	NA
PVD	Water-AC, 72, 58, 100	400	0.0	0	300	45	*0.128*	NA
PVD	Water-AC, 80, 68, 100	400	0.0	0	300	45	*0.128*	NA
EMS	DX, 75, NA, 120	12	0.6	0	NA	NA	NA	6.5
EMS	Water-WC, 80, 68, 120	16	0.7	0	2	6	0.184	NA
EMS	Water-WC, 72, 55, 120	20	1.0	0	12	7.5	0.370	NA
EMS	Water-WC, 72, 55, 120	40	2.0	0	15	14	0.370	NA

Energy Use Efficiency Model
Case: Chilled Water Cooling



PUE Calculation

Case: Chilled Water Cooled

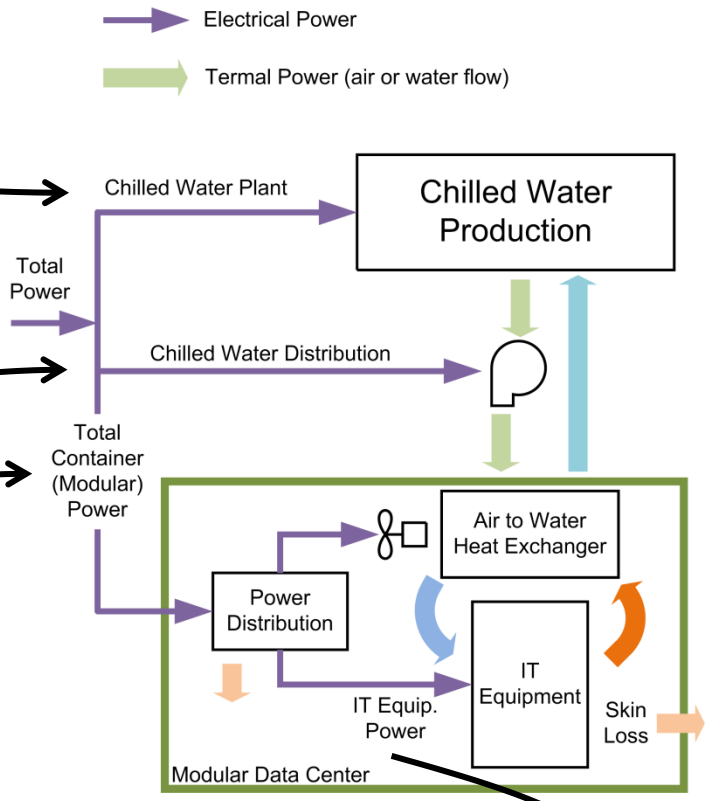
PUE = Total Power / IT Power

Chilled Plant Power (kW)
= ƒ (plant model, tons of cooling)
(model from Taylor Engineering)

tons of cooling (kW)
= ƒ (Total Power – Skin Loss, water temp.)

Chilled Water Distribution Pumping (kW)
= ƒ (water flow rate)

Total Modular Power (kW)
= ƒ (IT Equip., Fans, Power Dist. Loss)

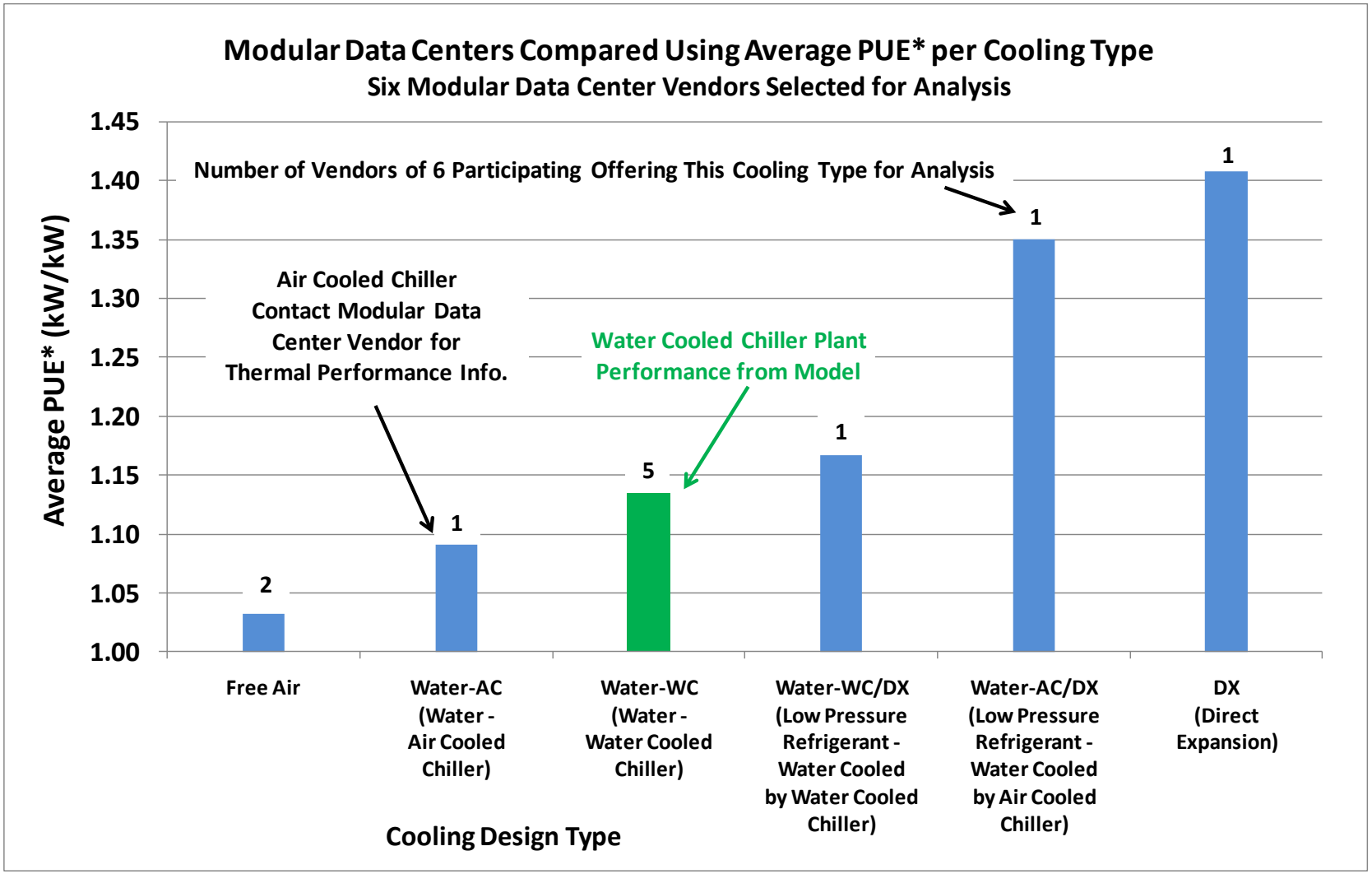


$$PUE = \frac{\text{(Chilled Plant Power + Water Dist. Pumping + Total Modular Power) = Total Power}}{\text{IT Equipment Power}}$$

Note: thermal data obtained from modular data center manufacturers, data not obtained by measurements

Details: http://hightech.lbl.gov/documents/data_centers/modular-dc-procurement-guide.pdf

Modular Data Center Thermal Analysis Results



Conclusions
For Modular Data Centers

- For temporary and permanent installation
- Possible lower capital cost and speedier deployment
- May be more efficient than traditional data centers
    - Better containment
    - Consistent mechanical design and thermal controls
    - Factory assembly
- IT equipment and modular data center can be provided by the same supplier, this may simplify warranty issues

Data Center Air Corrosivity Study

New/Related Topic - Outside Air Cooling and Corrosion Risk

- Some data centers owners are concerned that IT equipment may be more susceptible to corrosion damage if the primary source for cooling is outside air.

- To address the concern, in 2010 Lawrence Berkeley National Laboratory performed a limited corrosivity survey at 21 data center locations (19 in the US, 2 in India)

- Reactivity monitoring with Coupons is the common method for gaseous contamination measurement. Applicable Guideline: ANSI/ISA-71.04-1985

- Coupons were placed at air entrance and near the IT equipment

Reactivity Monitoring Corrosion Classification Coupon

before exposure

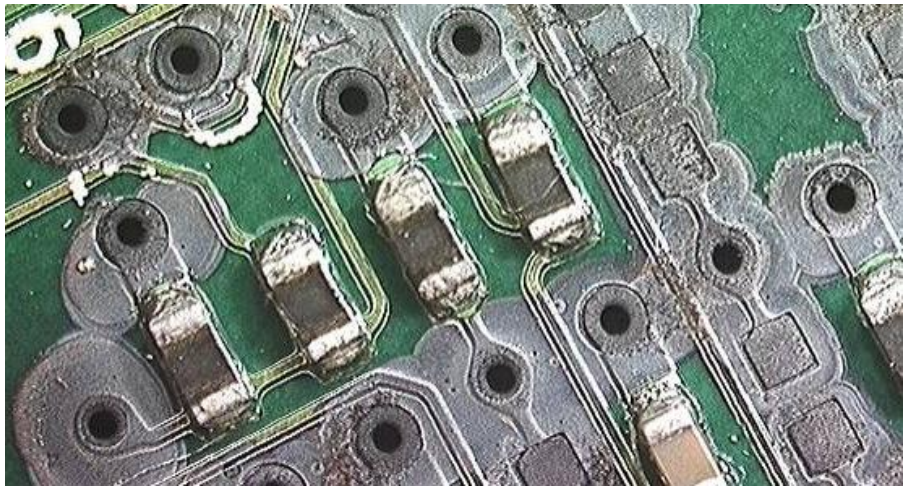
copper strip

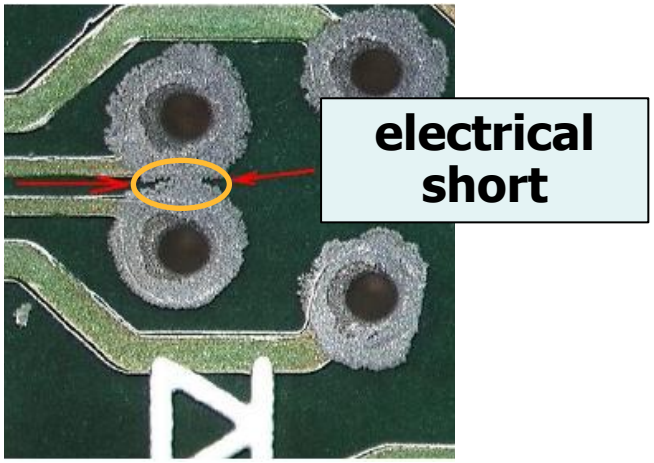
silver strip

after exposure

exposed for 30 or 60 days typical

Example of Creep Corrosion (not observed in our study)





ref. Free Air Cooling Poster-Randy Schueller-DFR Solutions

Inside Data Center Copper Coupon Measurement Levels: Not Problematic

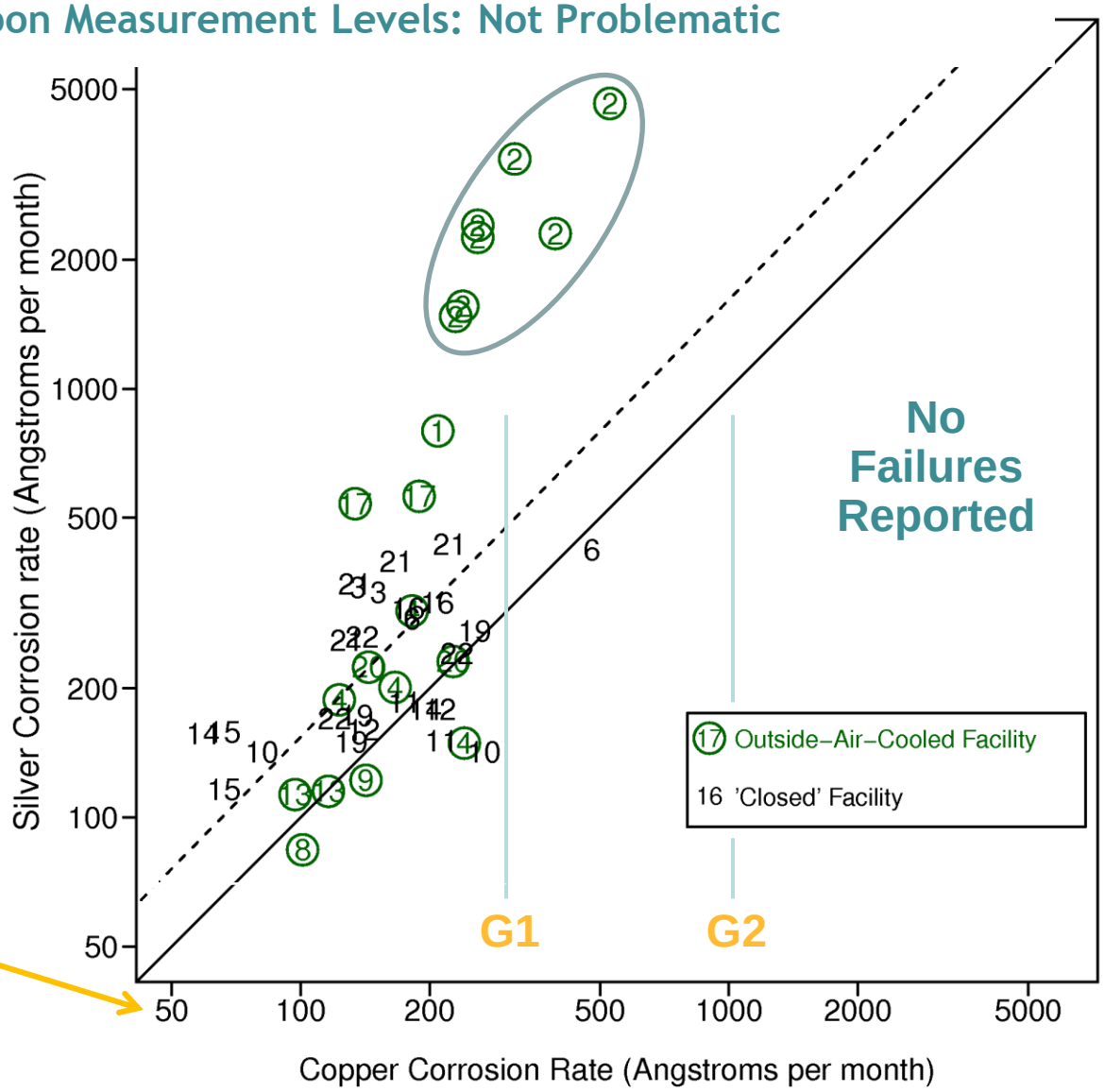
ANSI/ISA-71.04-1985
(lists copper only)

G1= <300 angstrom(Å)/mo. (mild, corrosion not a factor

G2= 300-1000 Å/mo. (moderate, corrosion may be a factor

silver not currently listed in an ANSI/ISA guideline

ANSI/ISA 71.04 1985 applies to copper only.



Conclusions

- Corrosion rate measurements at outside-air cooled and "closed" data centers are comparable.
- All copper measurements were below levels thought to be problematic – per ANSI/ISA 71.04 1985 severity table, level G1.
- No IT equipment failures reported at any data centers tested (21)
- Poor correlation between copper and silver corrosion rate measurements.
- Corrosion measurements had high variability at the monitored data centers.
- One U.S. site had comparatively high silver corrosion rate measurements but reported no failures. The copper measurement rates were not unusually high.
- Corrosion rate measurements measured outside were higher than those measured inside.
- <u>High silver corrosion rates are NOT a good predictor of reported higher IT equipment failure – per our observed data</u>

Presentation End

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