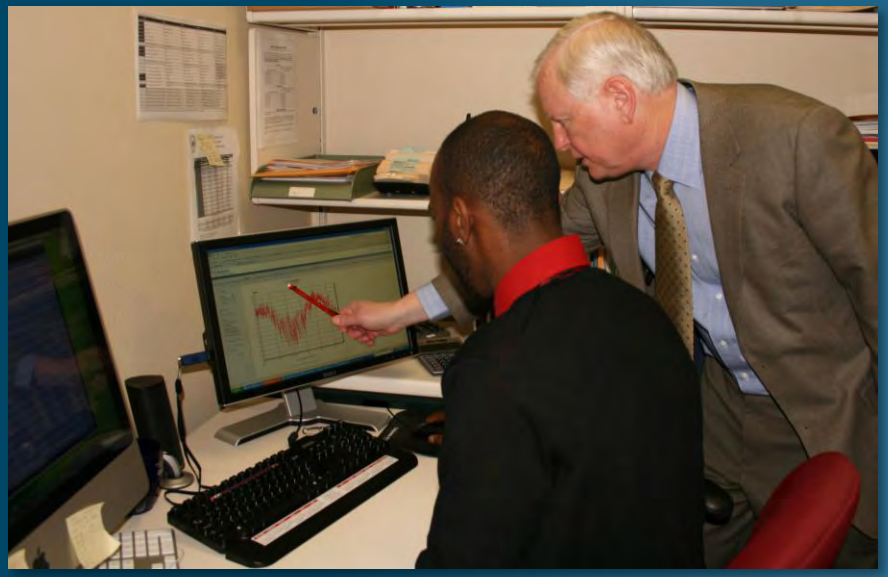
Evidence for Decision-Making in Optimal HVAC Operations



James M. Reilly

Image Permanence Institute

March 16, 2011

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Context

- Optimal HVAC operations
  - Doing the best you can with what you have
- Specifically:
  - Best environment for collections, building, staff and visitors
  - Least operating cost and consumption of non-renewable resources

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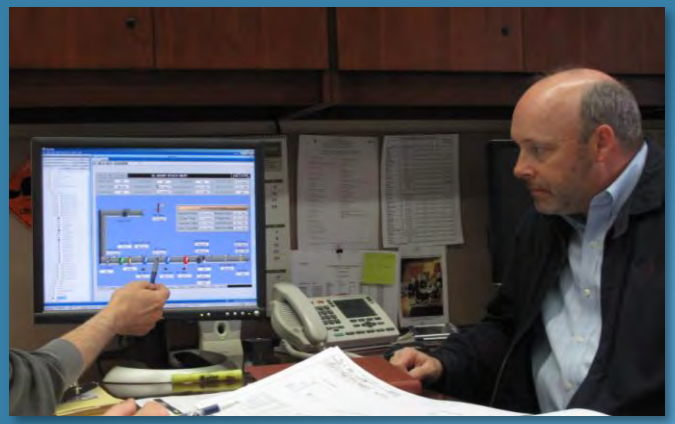
Dramatis Personae

Function	Titles	Role
Facilities Staff	Engineer Controls technician HVAC mechanic Facilities manager	Create the Environment



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Dramatis Personae

Function	Titles	Role
Collections Care Staff	Preservation officer Conservator Curator Librarian Archivist	Specify and evaluate the environment on behalf of the collections

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Dramatis Personae

Function	Titles	Role
Administration	Director CFO VP	Understand and enable the optimization process

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New Challenges for All Roles

- Collections care
  - Evaluate dynamic environmental changes made in the name of energy saving
  - Decide on acceptable environmental quality and tradeoffs (buck stops here)
  - Continuously collaborate with facilities
  - Understand basics of psychrometrics and HVAC

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New Challenges for All Roles

- Facilities
  - Investigate and test actions to save energy, reduce operating costs
  - Attain a holistic understanding of systems and controls
  - Understand the basics of collection preservation
  - Share ‘Driving the Bus’ with collections care

New Challenges for All Roles

- Administration
  - Make optimizing someone's job
  - Recognize the importance of optimal operation
  - Recognize it's a process of continuous improvement
  - Actively enable collaboration
  - Participate and communicate

The Essences

- Collections care has to know what the environment is, and what it means for the collections
- Facilities has to know they have the mandate for optimal operation and the guidance to avoid risks to collections
- Both must understand enough of each other's function to work effectively together

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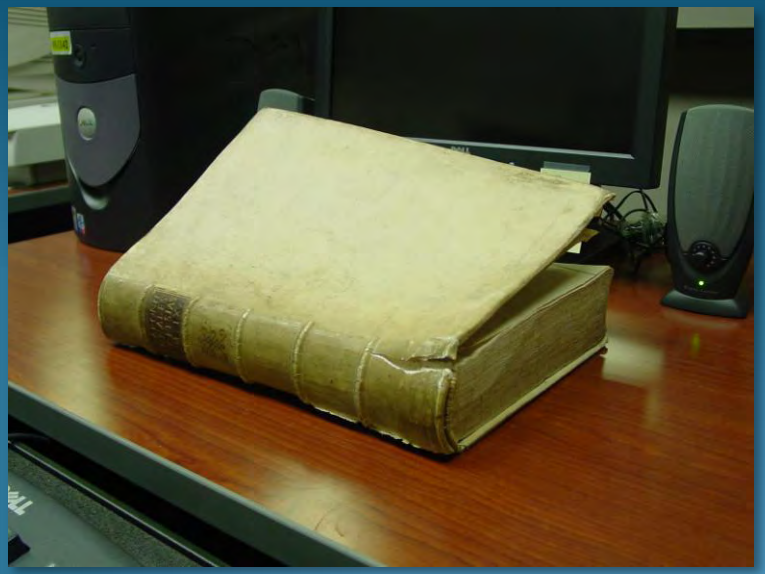
Evidence for Collections Care Decisions

- Data from collection spaces
- Metrics to compare and evaluate environmental effects on collections
- Documentation of energy savings



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Data From Collections Spaces

- Continuous
- Not trivial to get, organize and store
- Becomes more valuable with time
- Value of data is only realized through visualization, analysis and reporting software
- Cross-functional accessibility of data is important

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Why Environment is So Important to Archival Collections

- Materials degrade because
  - Paper, leather, textiles, plastics and dyes undergo spontaneous chemical reactions whose rate is determined by available heat and moisture
- Modern information media have been shown to degrade too rapidly at human comfort conditions

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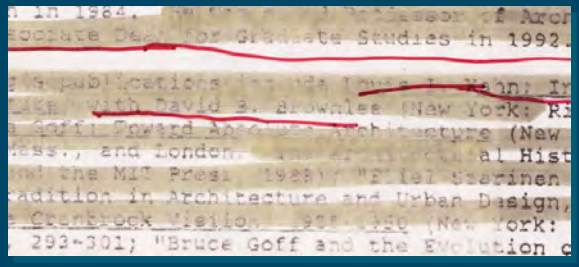
Chemical Change



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IPI's Research

- Data from more than 20 years of accelerated aging on plastics, gelatin, dyes
- The effects of storage environments on natural aging of such materials can be generalized and measured
- Preservation Index (PI)
  - TWPI (integral of changing conditions over time)

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IPI's Quantitative Decay Metrics

- Algorithms that process T & RH data into estimates of:
  - Natural aging rate
  - Mold risk
  - Physical risks from dryness, dampness, RH excursions
  - Metal corrosion risk
- Integrations over time to quantify benefits as well as risks

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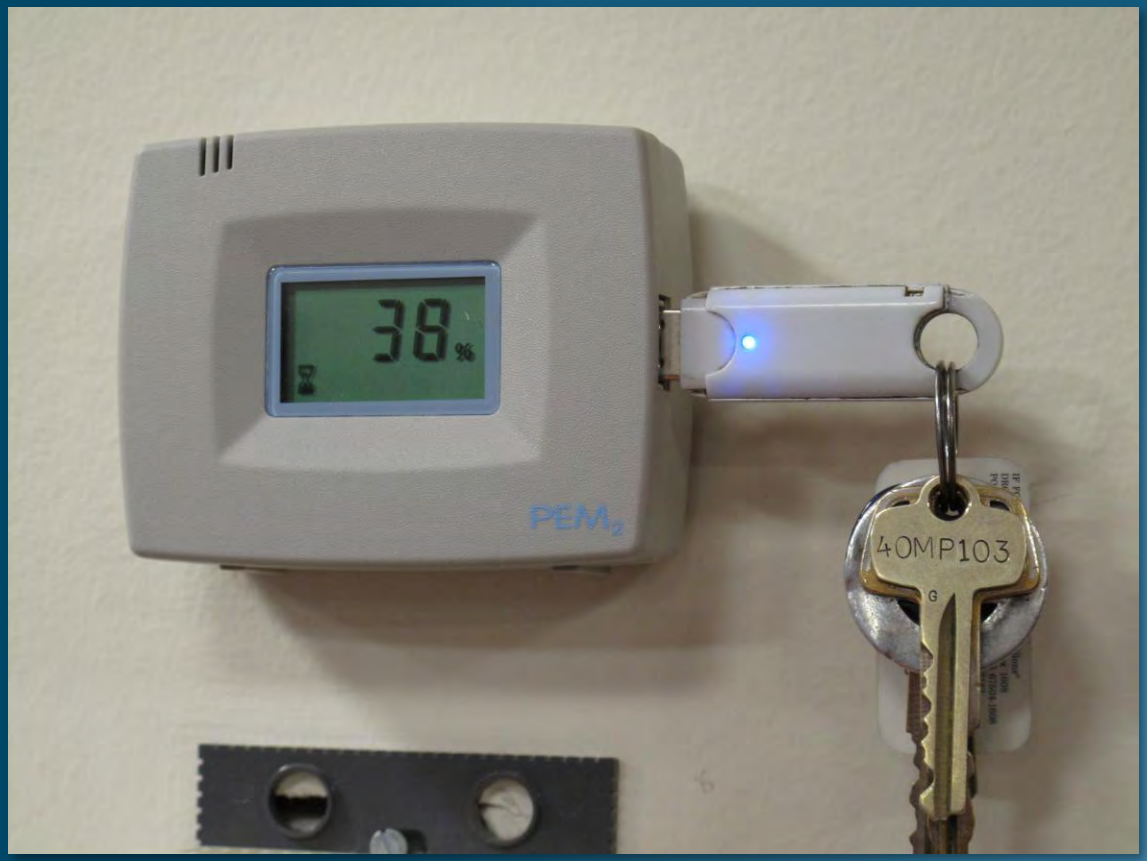
IPI's Tools for Data Collection, Organization and Analysis

- PEM2 Datalogger



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IPI's Tools for Data Collection, Organization and Analysis

- www.DPCalc.org
  - Interactive psychrometric chart with preservation guidance

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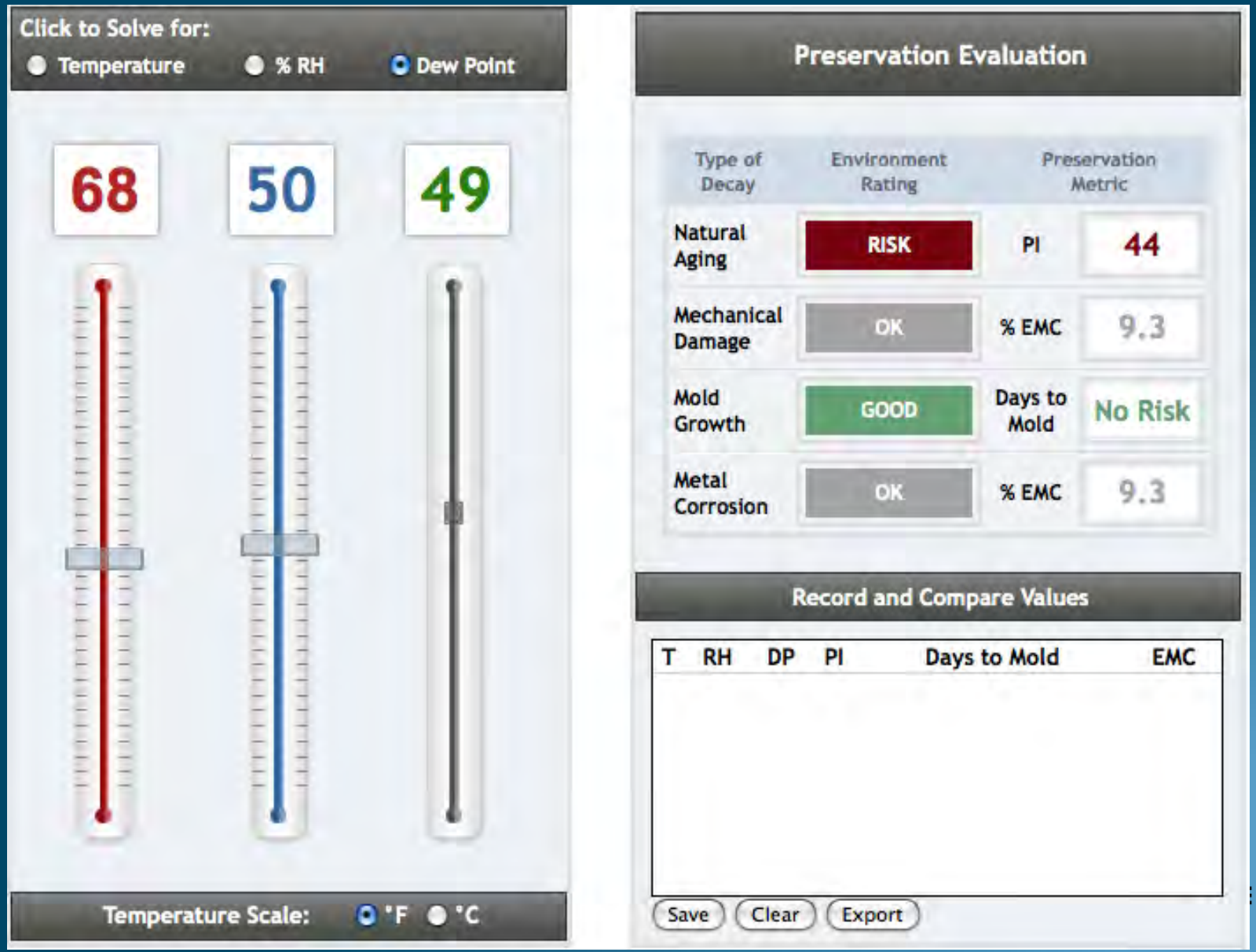
DPCalc.org


Click to Solve for:
Temperature
% RH
Dew Point
68
50
49
Temperature Scale:
°F
°C
Preservation Evaluation
Type of Decay
Environment Rating
Preservation Metric
Natural Aging
RISK
PI
44
Mechanical Damage
OK
% EMC
9.3
Mold Growth
GOOD
Days to Mold
No Risk
Metal Corrosion
OK
% EMC
9.3
Record and Compare Values
T
RH
DP
PI
Days to Mold
EMC
Save
Clear
Export

IPI's Tools for Data Collection, Organization and Analysis

- www.PEMData.org
  - Free, secure website for data storage, graphing, preservation metrics calculation

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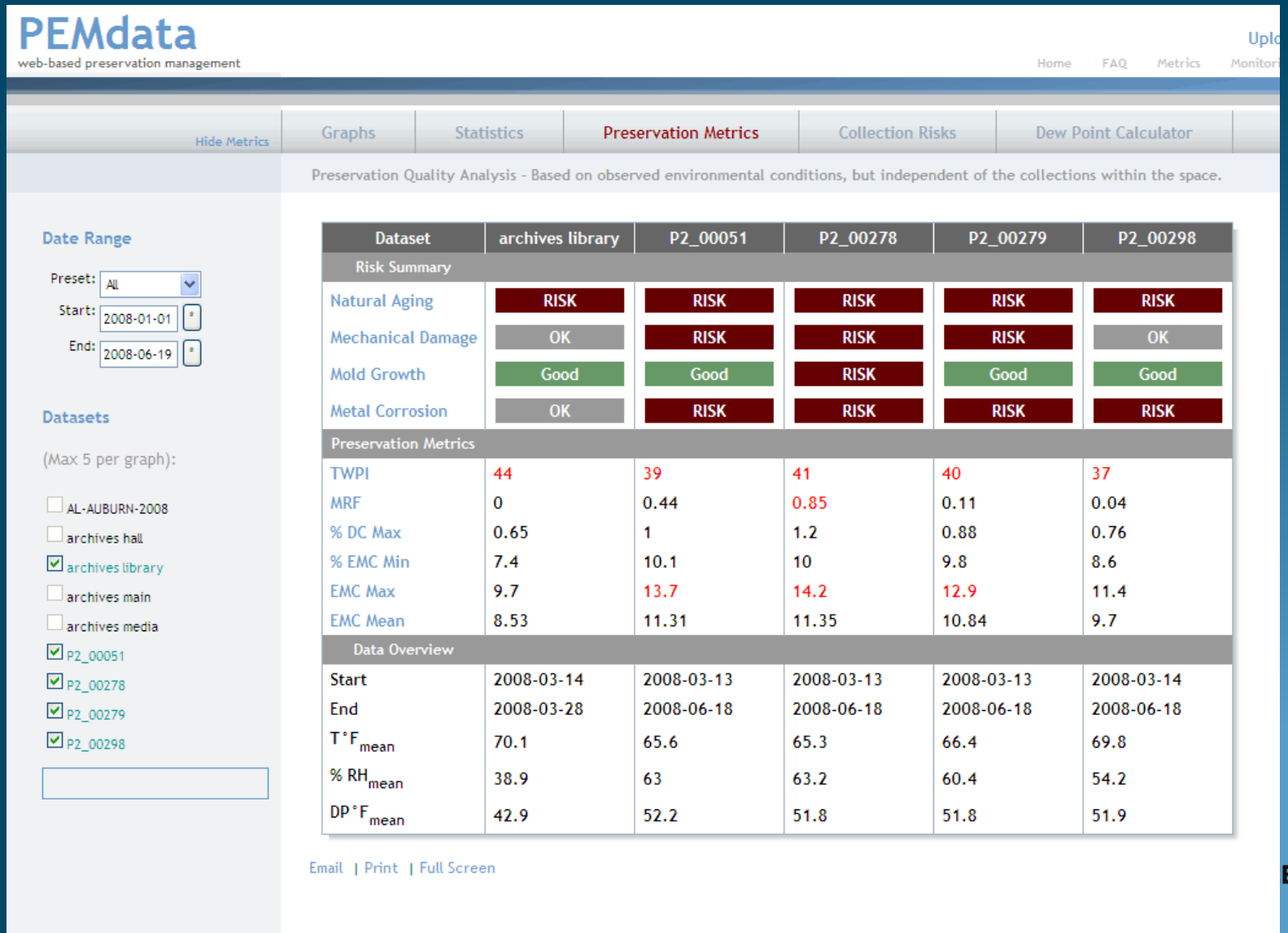
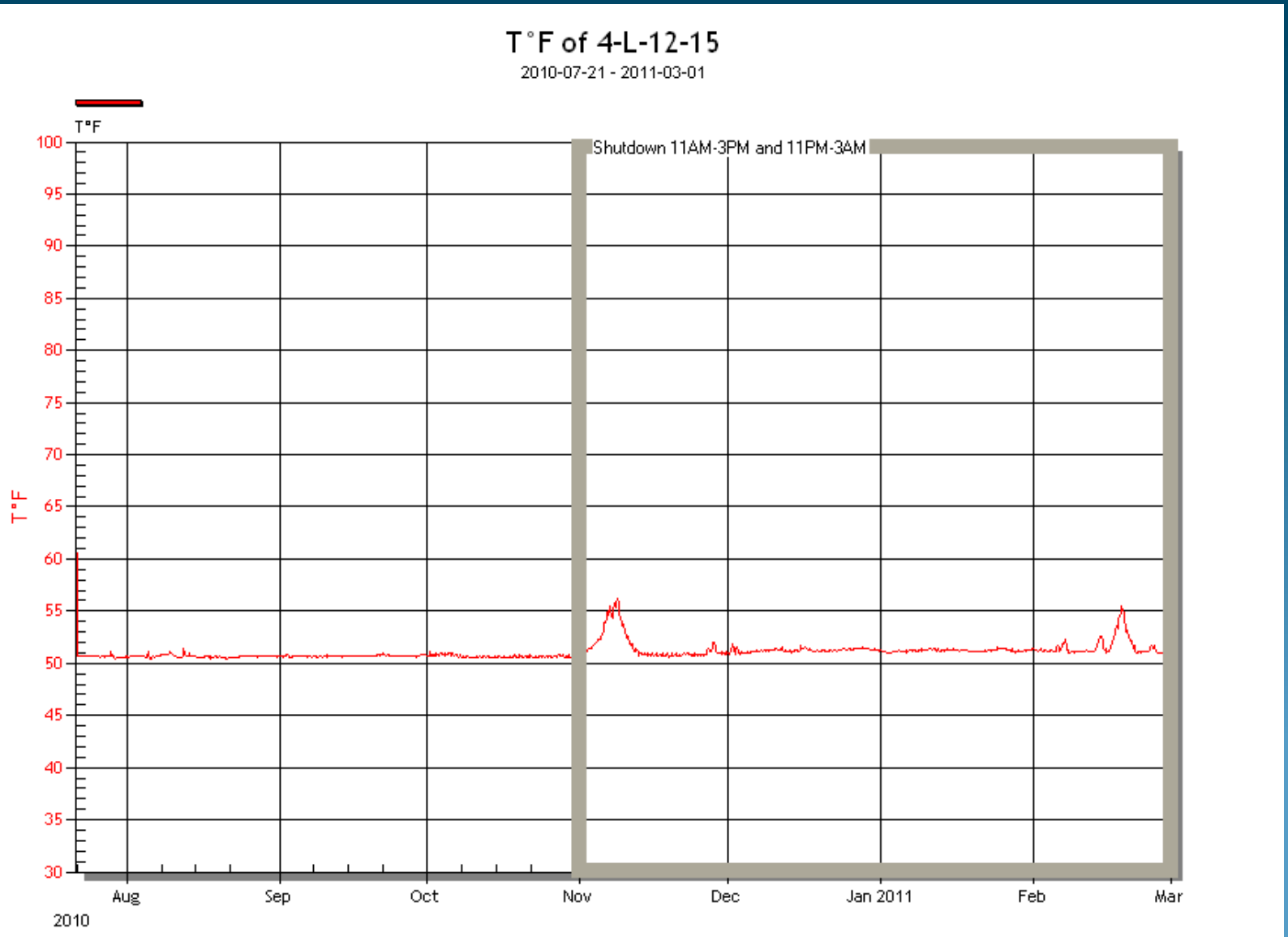
Preservation Metrics in Practice

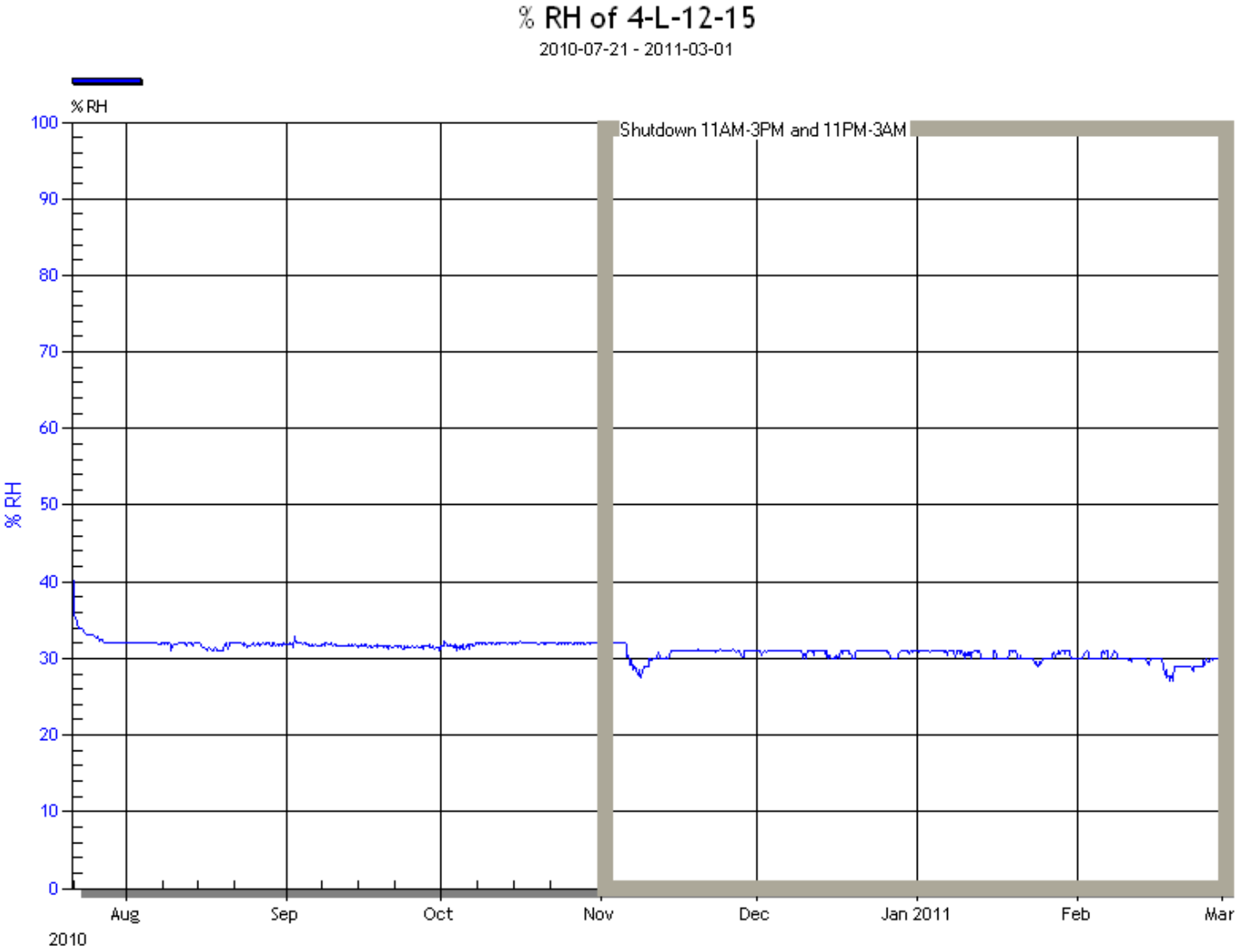


Dataset	archives library	P2_00051	P2_00278	P2_00279	P2_00298
Risk Summary					
Natural Aging	RISK	RISK	RISK	RISK	RISK
Mechanical Damage	OK	RISK	RISK	RISK	OK
Mold Growth	Good	Good	RISK	Good	Good
Metal Corrosion	OK	RISK	RISK	RISK	RISK
Preservation Metrics					
TWPI	44	39	41	40	37
MRF	0	0.44	0.85	0.11	0.04
% DC Max	0.65	1	1.2	0.88	0.76
% EMC Min	7.4	10.1	10	9.8	8.6
EMC Max	9.7	13.7	14.2	12.9	11.4
EMC Mean	8.53	11.31	11.35	10.84	9.7
Data Overview					
Start	2008-03-14	2008-03-13	2008-03-13	2008-03-13	2008-03-14
End	2008-03-28	2008-06-18	2008-06-18	2008-06-18	2008-06-18
$T°F_{mean}$	70.1	65.6	65.3	66.4	69.8
$\%\ RH_{mean}$	38.9	63	63.2	60.4	54.2
$DP°F_{mean}$	42.9	52.2	51.8	51.8	51.9

Cornell Annex Shutdown



Cornell Annex Shutdown



Energy Saving Scenarios

- Reducing
  - Time of operation
  - Air volumes
  - Outside air
- Changing
  - Set points
  - Operating theory (rethink / re-engineer)

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Evidence for Energy Savings

- Documentation of before and after
  - Dataloggers in Air Handlers
    - Upstream and downstream of cooling and heating coils
    - Measurements of fan amps
  - Dataloggers in supply and return ducts
  - Preservation metrics show collection impact
  - Estimates of dollar costs based on logger data, utility costs, air volumes

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Conclusion

- Administration role is central
- This is not a project, it's a process of active collaboration, involves new tasks, and continues indefinitely
- Data and documentation required
- IPI tools directly support optimization, quantify collection risks and benefits
- Big systems, big money

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