Winter, ACC's, and Lost MW's

James Koch
Performance Consultant
www.heatrate.com

Christopher Haynes
Author of FCYCLE, CCYCLE, NCYCLE
Plant Design and Operations
Power Software Associates, Inc.

Dr. Melanie Derby
Professor of Mechanical Engineering
Specializing in Heat Transfer and Condensing
Kansas State University

Winter, ACC's, and Lost MW's

- Winter back pressures are too high
- The resulting MW loss can be significant (up to 5% of STG MW's)
- The loss depends on "End Loading"
- The high backpressures are due to high air in-leakage, metal wastage concerns, freezing concerns
- Heatrate.Com and Power Software are developing instrument and control mods to minimize these losses.

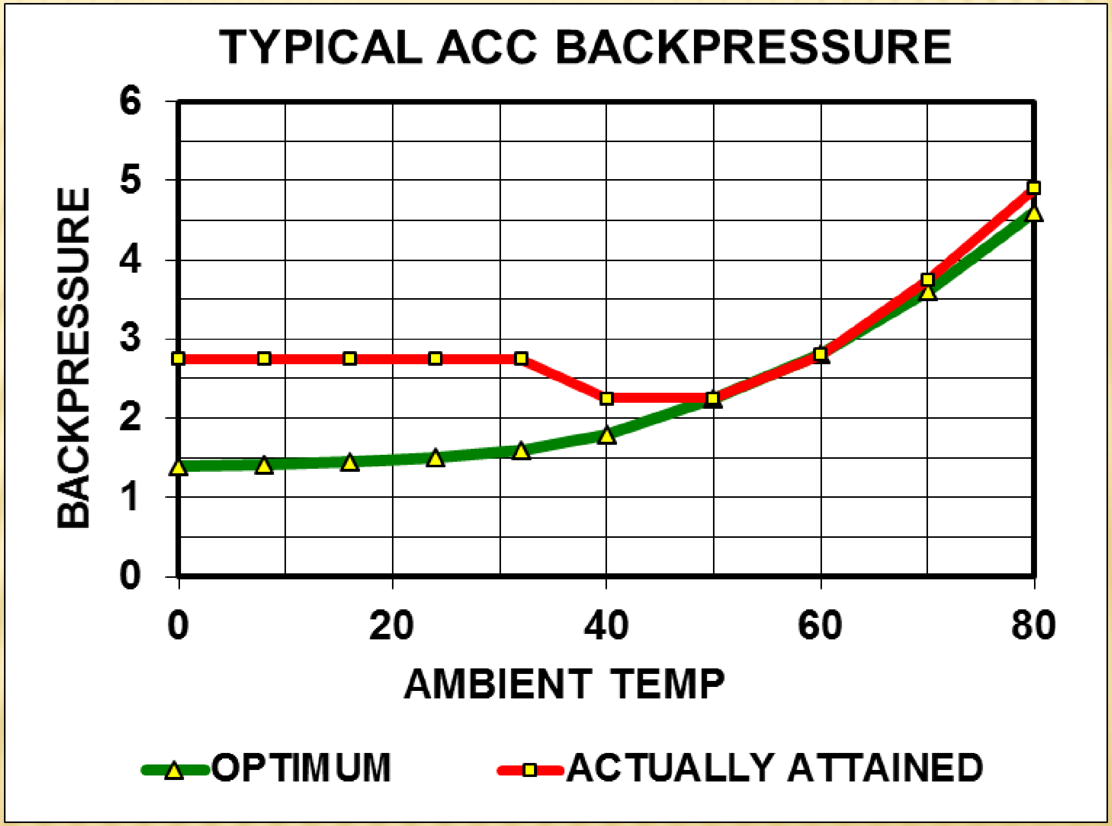
Winter, ACC's, and Lost MW's

- Jim Koch, Performance Consultant, www.heatrate.com, 30+ years in Power Plant Testing, Modeling, and Analysis
- Chris Haynes, Power Software Associates 40+ years in Plant Design and Operations Author of FCYCLE CCYCLE NCYCLE
- Dr. Melanie Derby, Kansas State University Professor of Mechanical Engineering, Interest in Heat Transfer & Condensing

Summer Backpressure

Winter Losses due to High Backpressure

Many steam turbines operate at higher than optimum backpressures during the winter



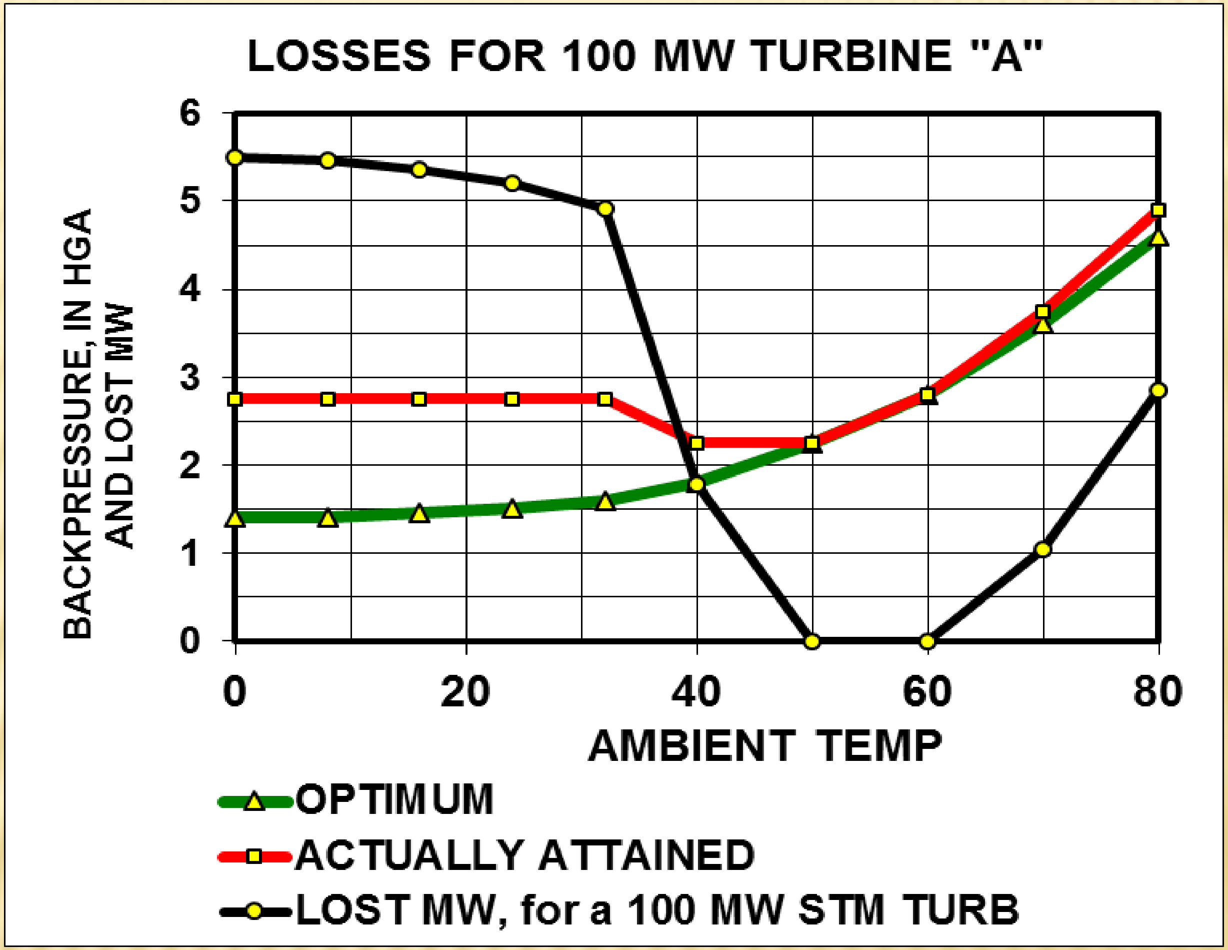
Winter Losses due to Backpressure

- Owners know that high backpressure is bad
- This is usually only a summertime concern
- Owners are often unaware of possibility of lost MW's during the winter
- The loss can often be 5% of STG MW's
- For a 100 MW STG, this can be up to $1.5 million ***per winter*** with high power prices
- These losses are unit specific

Rule of Thumb ?

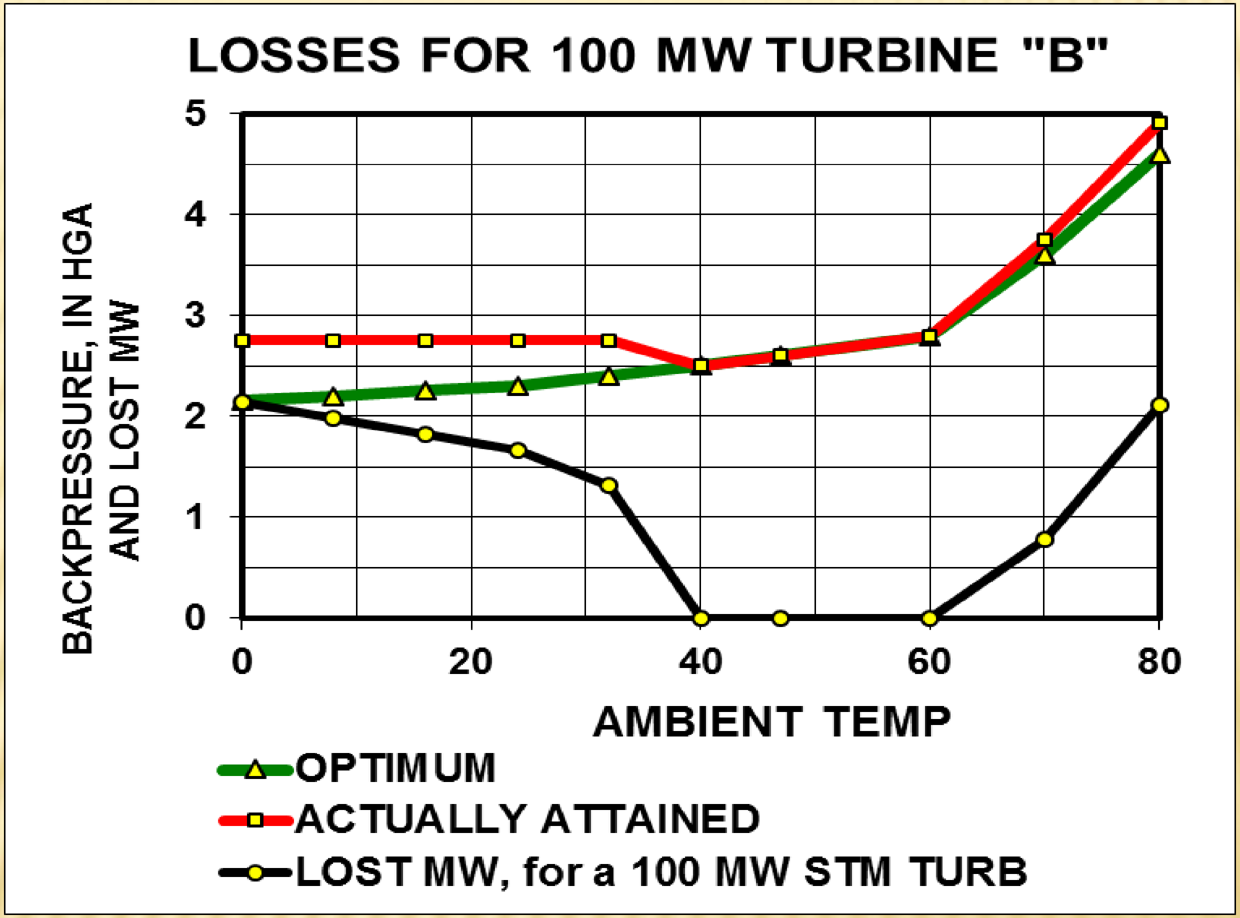
- Years ago, common adage was “1 inch equals 1%”
- This is INCORRECT ! !
- The rule of thumb is that there is NO rule of thumb
- The relation between back pressure and MW’s is UNIT SPECIFIC

Turbine A



Up to 5% of output can be lost.

Turbine B



Losses are, at most, 2% of output.

Turbine A vs Turbine B

- Turbine A and Turbine B have very different losses due to high backpressure
- The difference is due to the size of the last stage blade, relative to steam flow
- This is called the “End Loading”

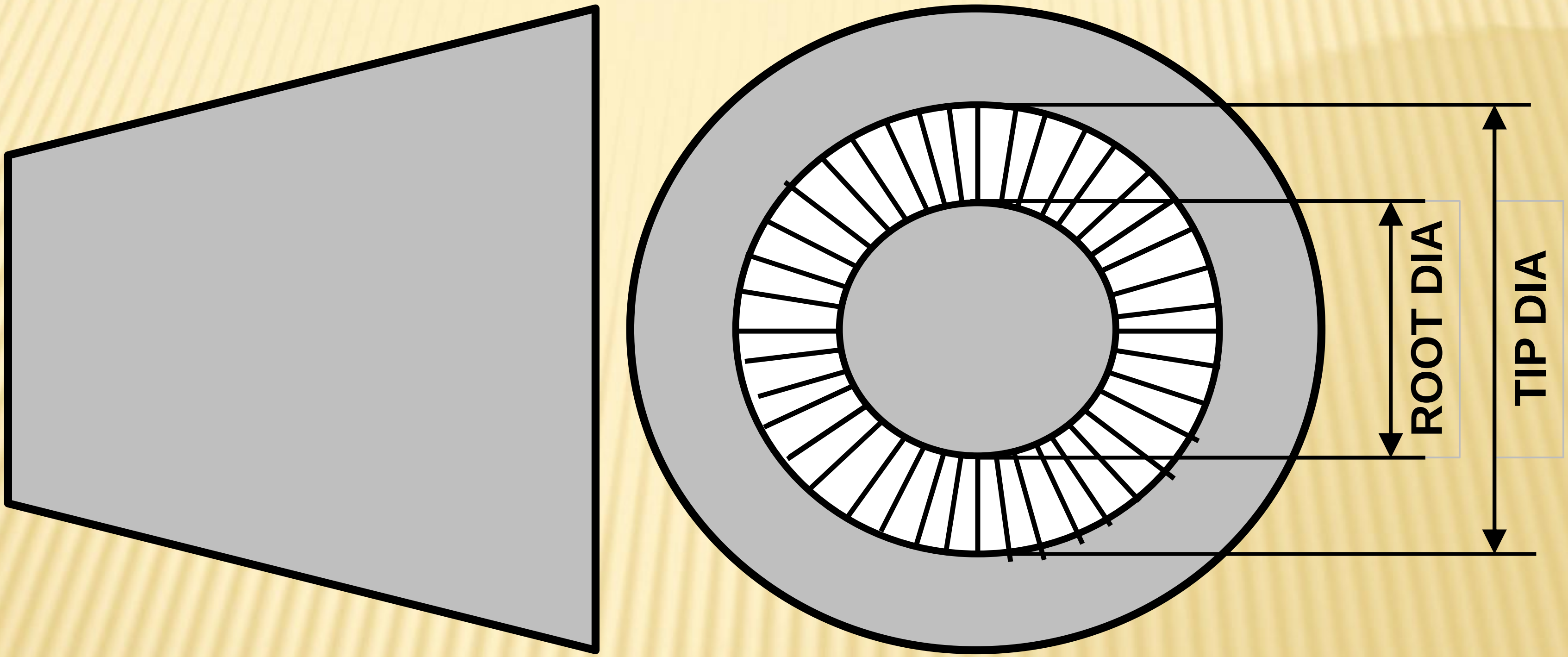
End Loading

What is "End Loading?

End Loading = ___Lb/hr of exhaust steam flow___
(Square feet of exhaust flow area)

Very Small Last Stage: 18,000 lb/hr-sqft
Very Large Last Stage: 6,000 lb/hr-sqft

Exhaust Flow Area



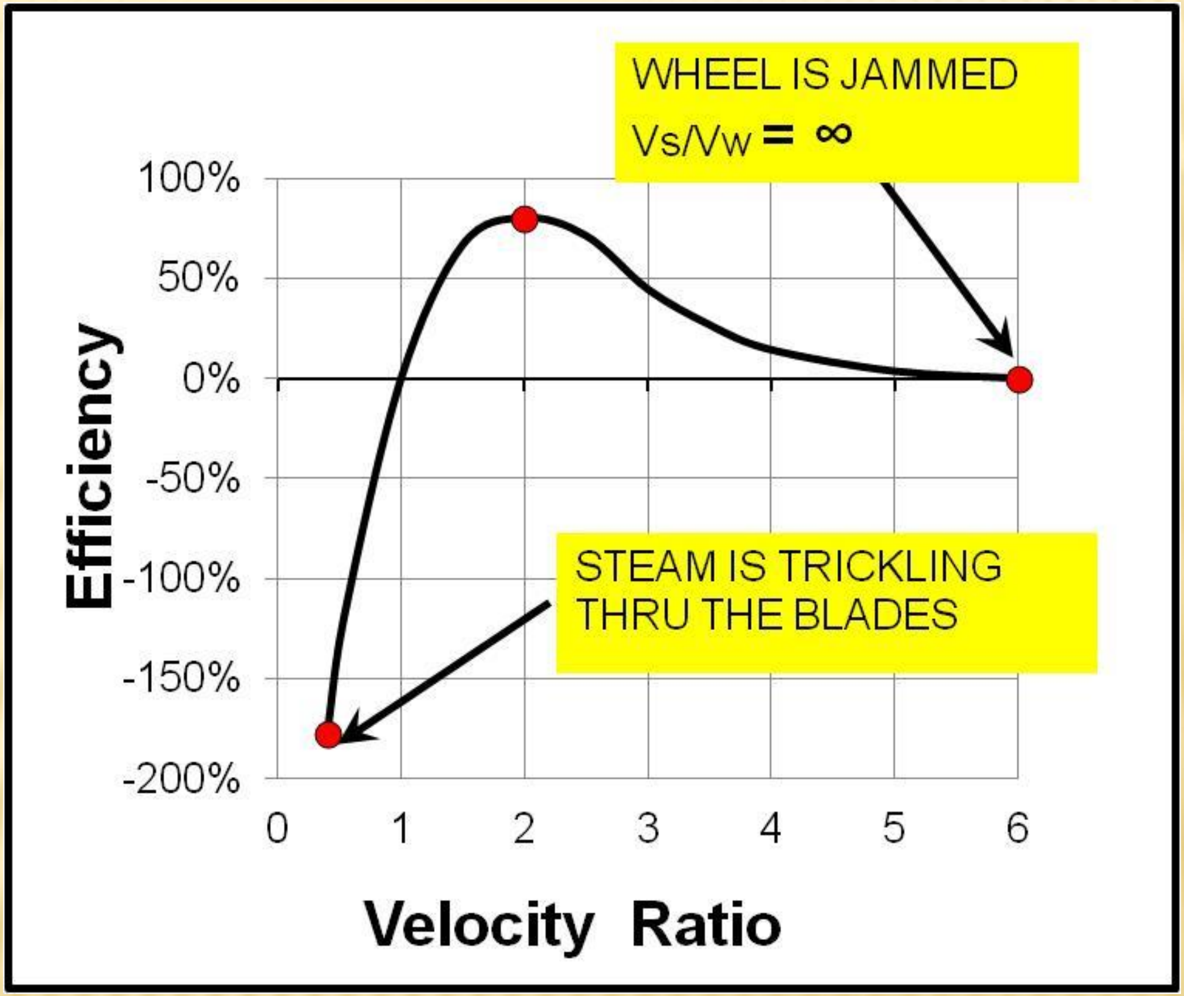
End Loading

Q. Why does End Loading matter?

A. It sets the Blading Efficiency, for any given steam flow and backpressure

- **End Loading determines Steam Velocity**
- **Steam Velocity determines Velocity Ratio**
- **Velocity Ratio determines Blading Efficiency**

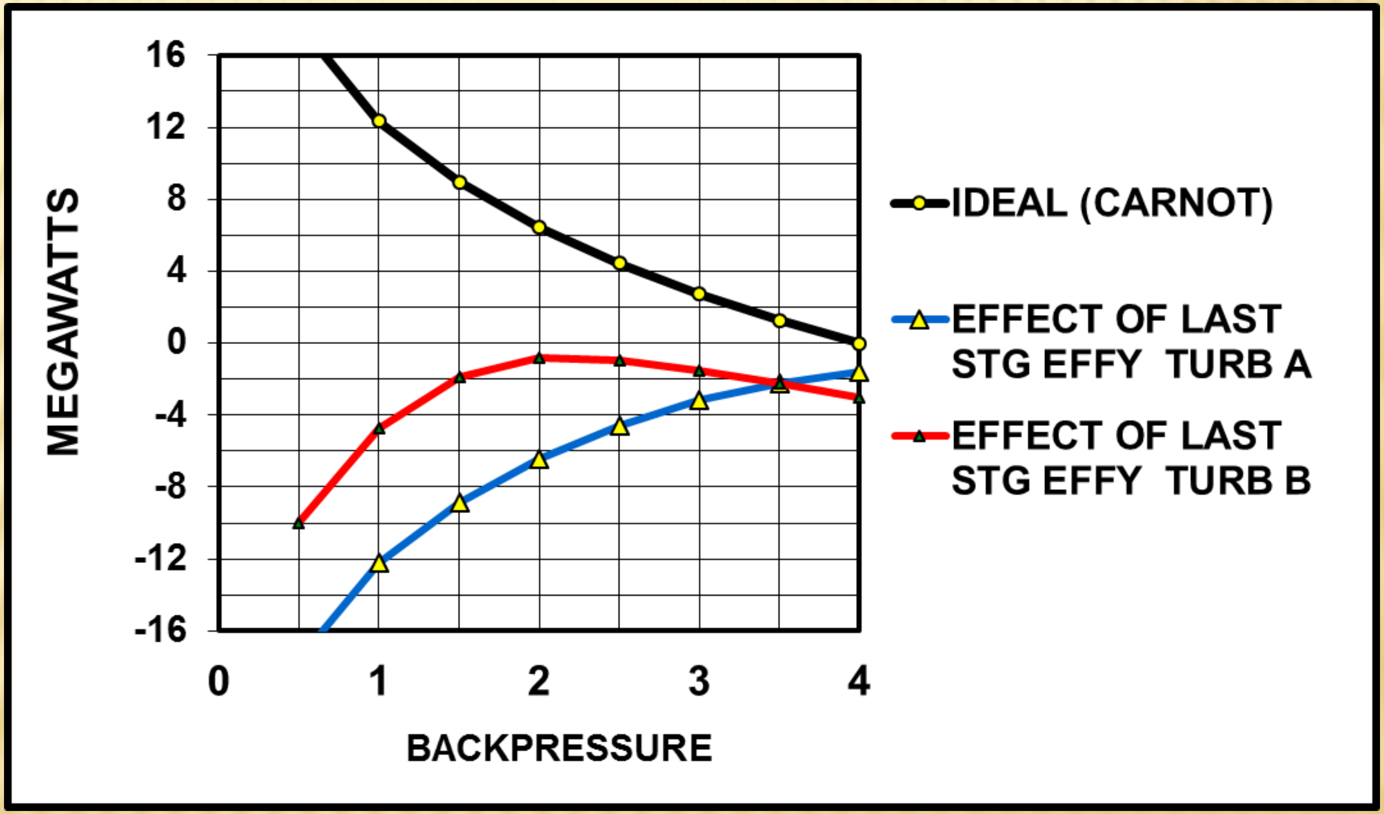
Efficiency Depends on Velocity Ratio



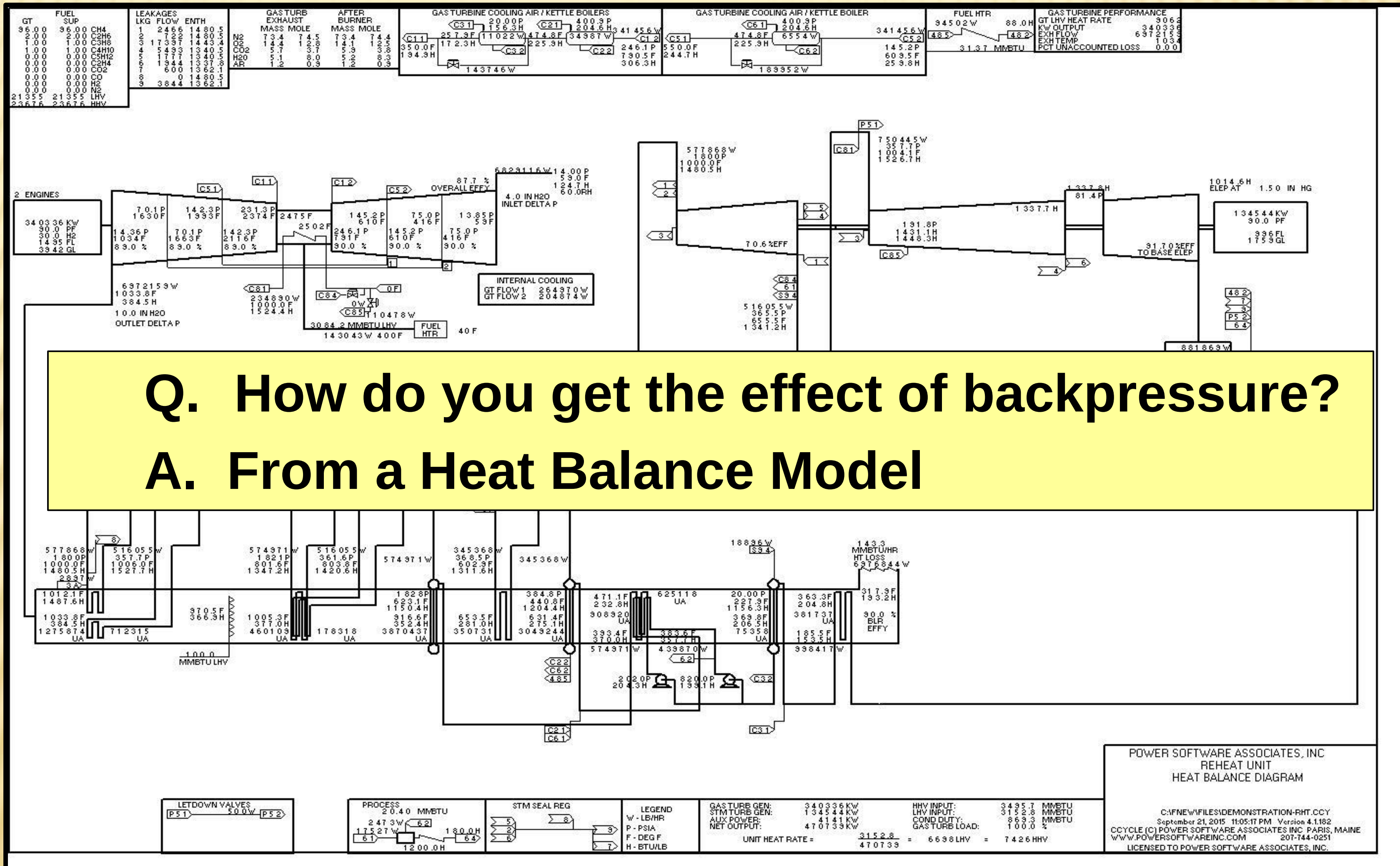
How does Backpressure affect MW's?

Backpressure has two effects:

1. **Ideal (Carnot) cycle efficiency changes**
2. **Last stage blade efficiency changes**



How does Backpressure affect MW's?



Q. How do you get the effect of backpressure?

A. From a Heat Balance Model

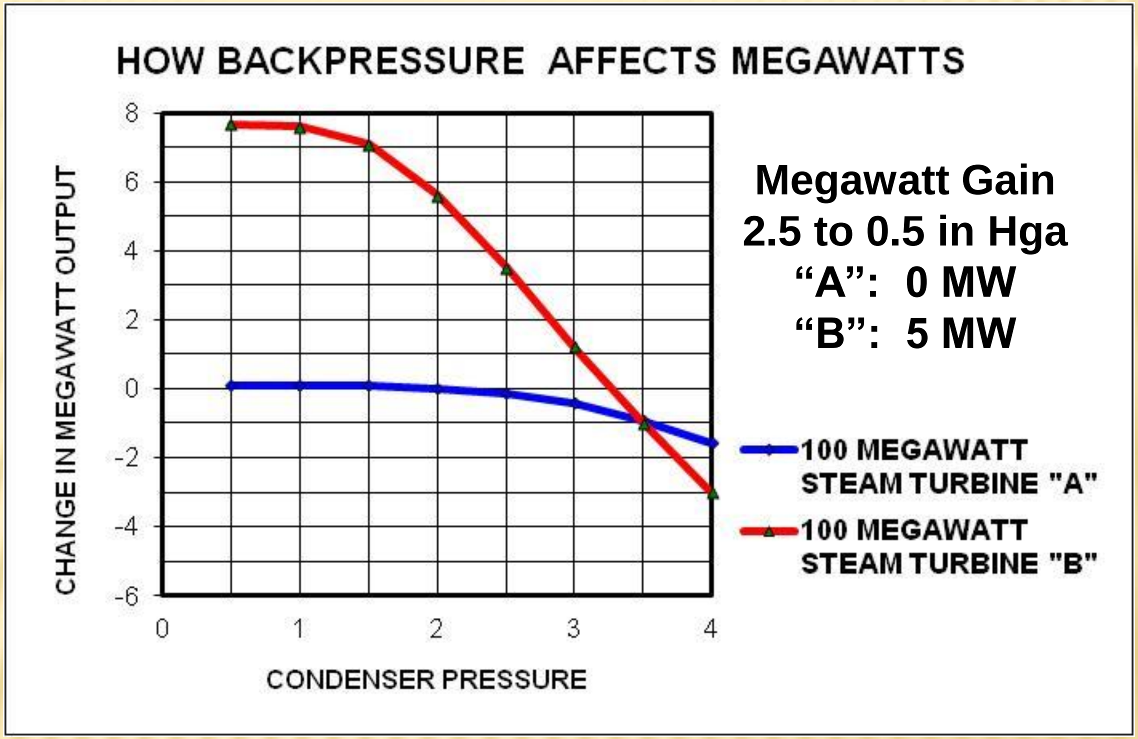
Power Software Associates

The $64,000 question

heatrate.com

How does Backpressure affect MW's?

Megawatt losses vary from one unit to another.

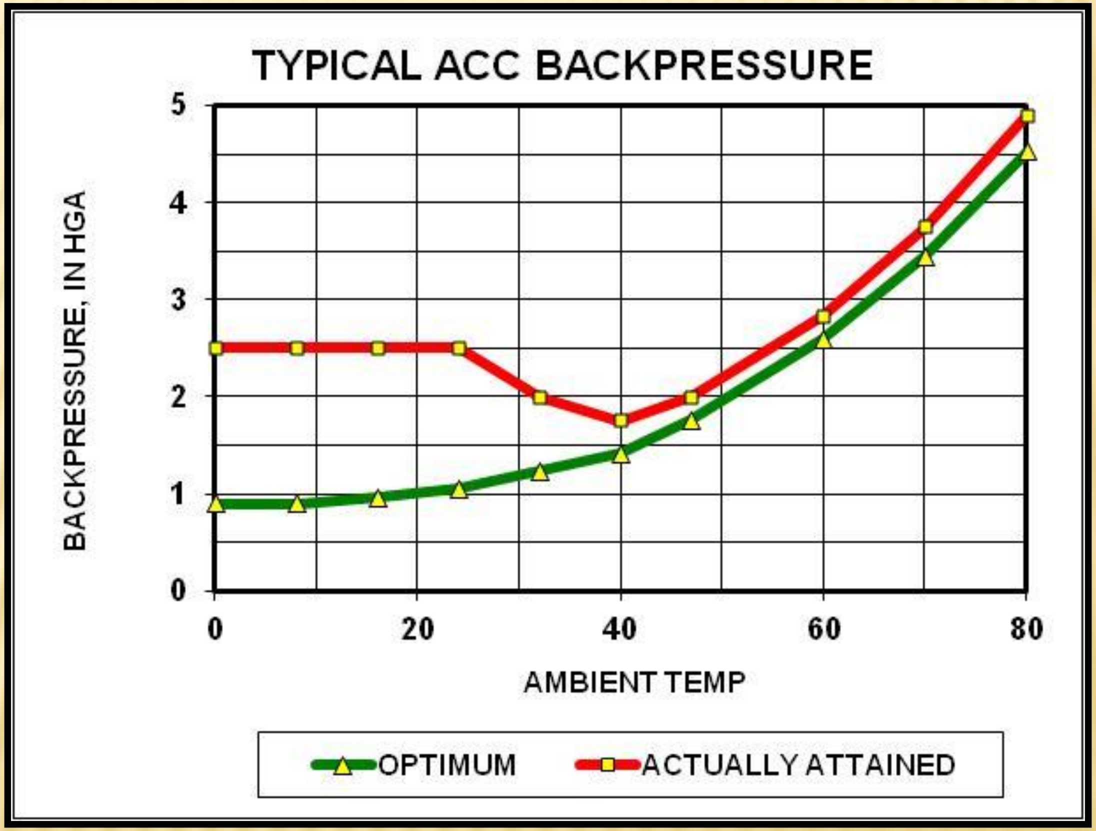


A has larger last stage, lower end loading
B has smaller last stage, higher end loading

Winter Time Backpressure

Revisit typical curve of back pressure vs. ambient T

Focus on region between 32 F and 40 F



Backpressure, Dollars, and Freezing

- The trade-off between backpressure and enhanced freezing protection methods depends on End Loading

- In HIGHLY End Loaded Units, there is LITTLE advantage to reducing backpressure

- In LIGHTLY End Loaded Units, there is GREAT advantage to reducing backpressure

Why are Winter Backpressures so high?

1. High air In-Leakage

2. Erosion concerns

3. Freezing concerns

In-Leakage and Winter Backpressure

- **High air in-leakage can increase backpressure. *It also increases danger of freezing.***
- **ACC's are more susceptible to air in-leakage than water cooled units**
- **Air removal pumps have less capacity when backpressure is low**

Backpressure and Erosion concerns

- " Erosion" includes both conventional erosion and flow accelerated corrosion (FAC).
- Both are worsened at LOW backpressure, as velocity and amount of moisture increase
- FAC is being mitigated with chemistry control
- Progress in corrosion mitigation now makes lower backpressures achievable.

Need for Better ACC Freeze Protection

- **Conservative freeze protection procedures prevent plants from taking advantage of achievable lower winter back pressure**
- **When "not quite freezing" these guidelines are too restrictive, margins are overly-conservative**

Need for Better ACC Freeze Protection

- Visited a 125MW STG site with 18 cell ACC
- 1 condensate drain temperature reading per K-cell
- Provided limited information to operators
- As a result, Operators are discouraged from being too aggressive in winter, leaving MW's "on the table"

Development of Improved Freeze Protection Instrumentation and Control

- 15 temperature readings are too few
- 1,000,000 readings are better

Development of Improved Freeze Protection Instrumentation and Control

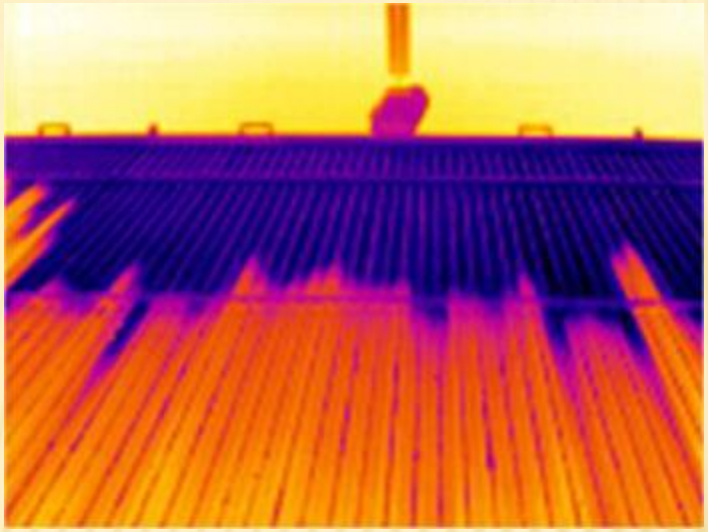
- **Development, simulation and field testing of Improved Instrumentation and Controls (*patent pending*) Technology**

- **Program to be undertaken by heatrate.com and a selected "Alpha Site"**

- **Pursue "Beta Site" opportunities**

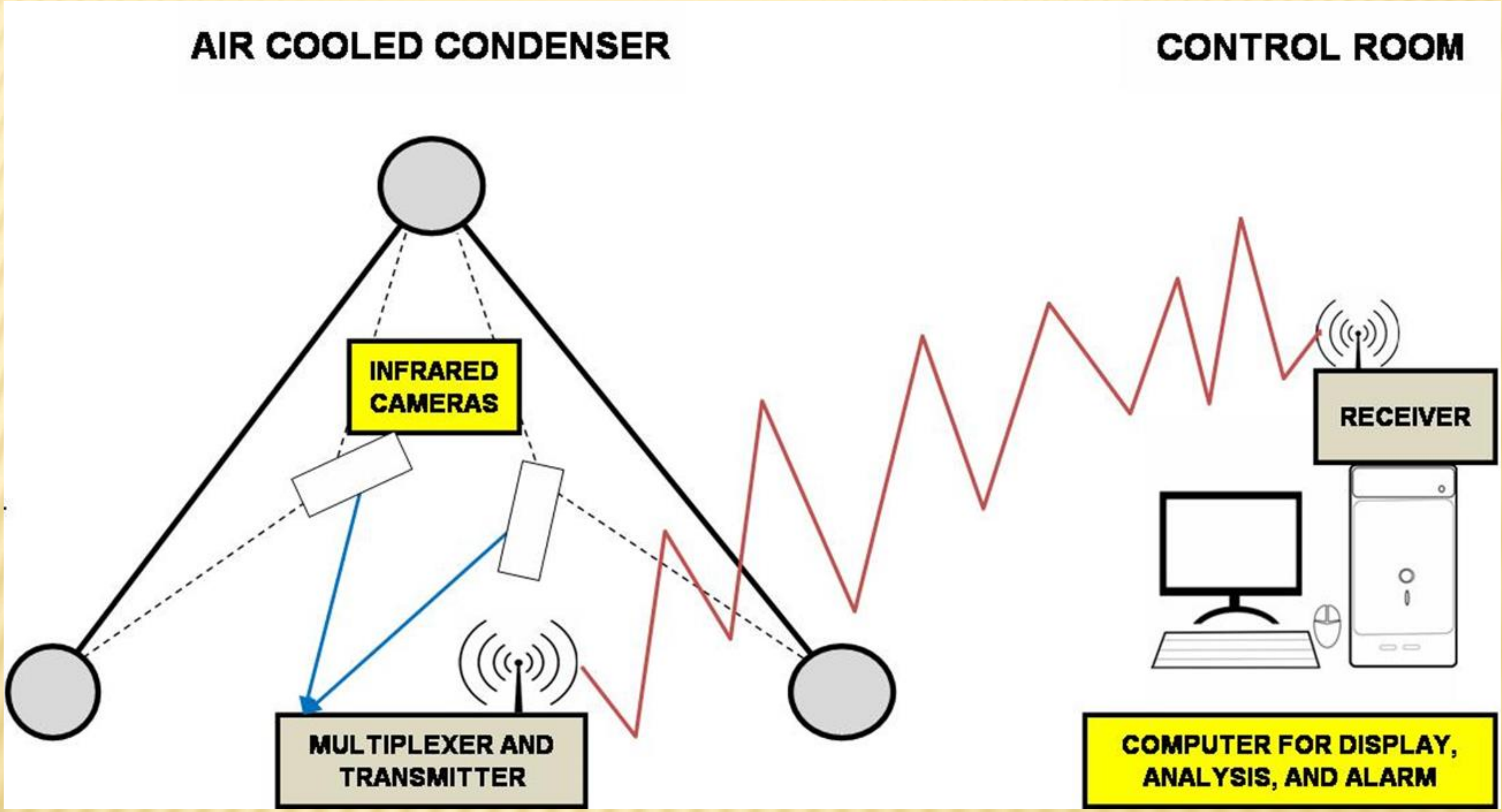
- **How to monitor temperature at 1,000,000 locations on the ACC ?**

Thermography Measurement, ACC Fan Control System



- **IR Thermograpghy will locate cold ACC tubes**
- **These will be displayed and alarmed in the control room, and digitized to provide control system input**
- **The Plant DCS control computer will "burp" the air pockets from the condenser**

Development of Improved Freeze Protection Instrumentation and Control



Development of Improved Freeze Protection Instrumentation and Control

Tasks:

- **Development and field testing of thermography measurement, display and digitizing technology**
- **Simulation and field testing of burping methods to expel air pockets to prevent freezing**
- **The "Burp-o-matic" (*patent pending*)**

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