# Steam Cycle Chemistry in Air-Cooled Condensers

**NV Energy ACC User's Group * November 12-13, 2009**

**Andrew Howell * Xcel Energy**

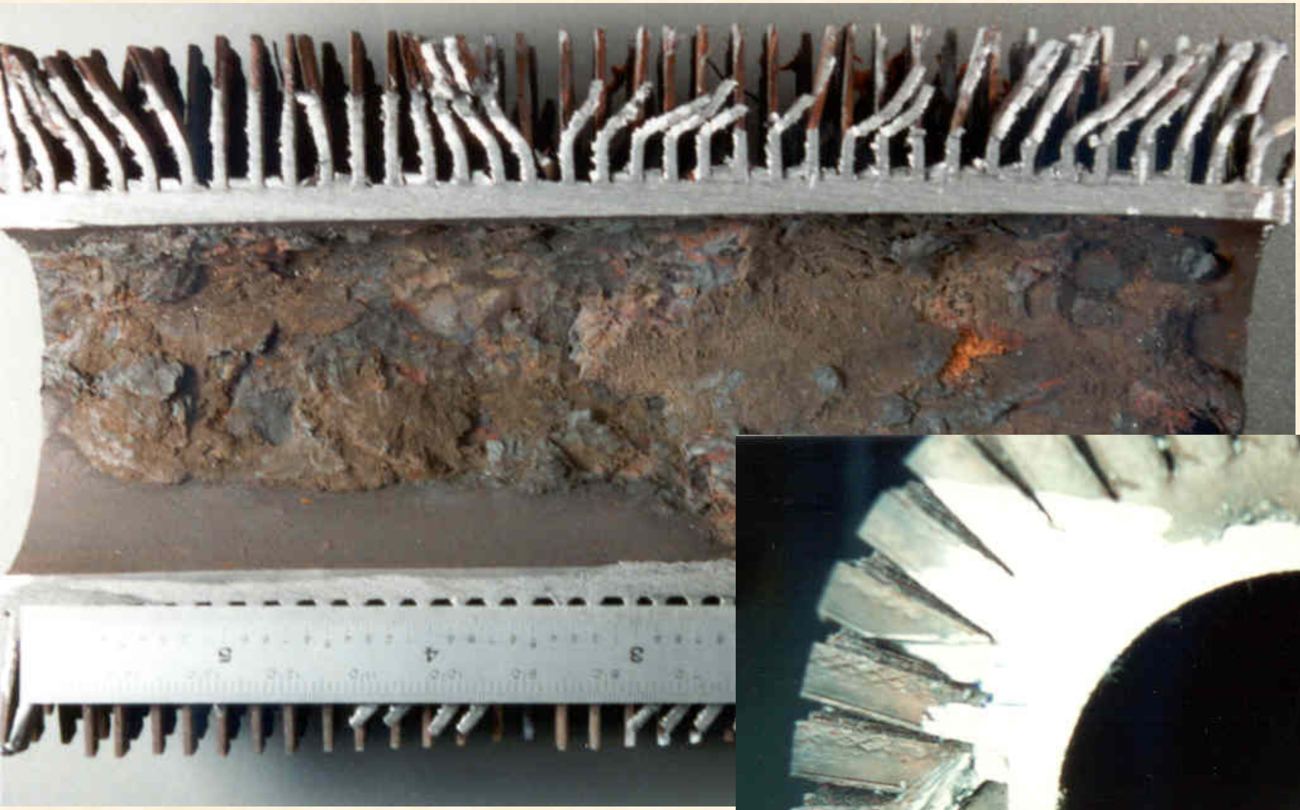
# Steam Cycle Chemistry Goal for ACC:

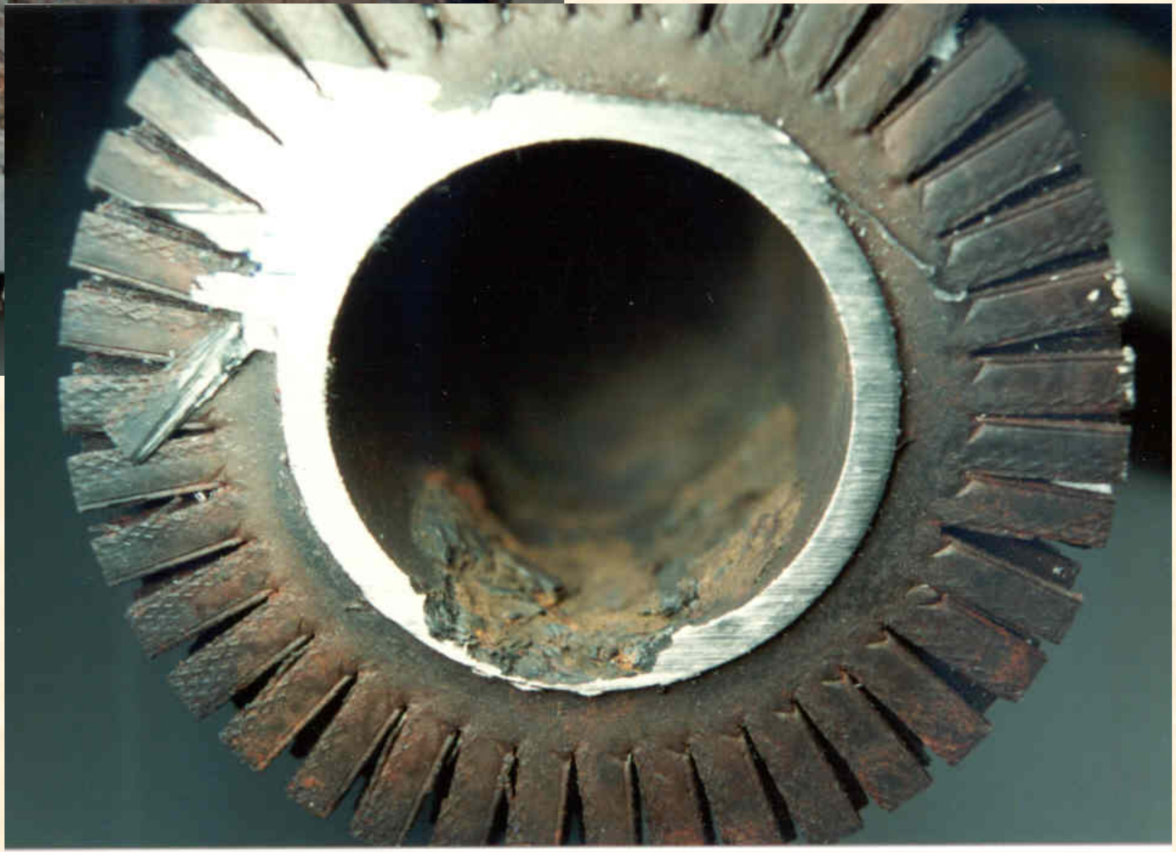
# minimize corrosion of carbon steel

**Resulting in:**

- **minimal particulate transport (iron oxide)**
- **minimal through-wall leaks**

# Consequences of particulate transport

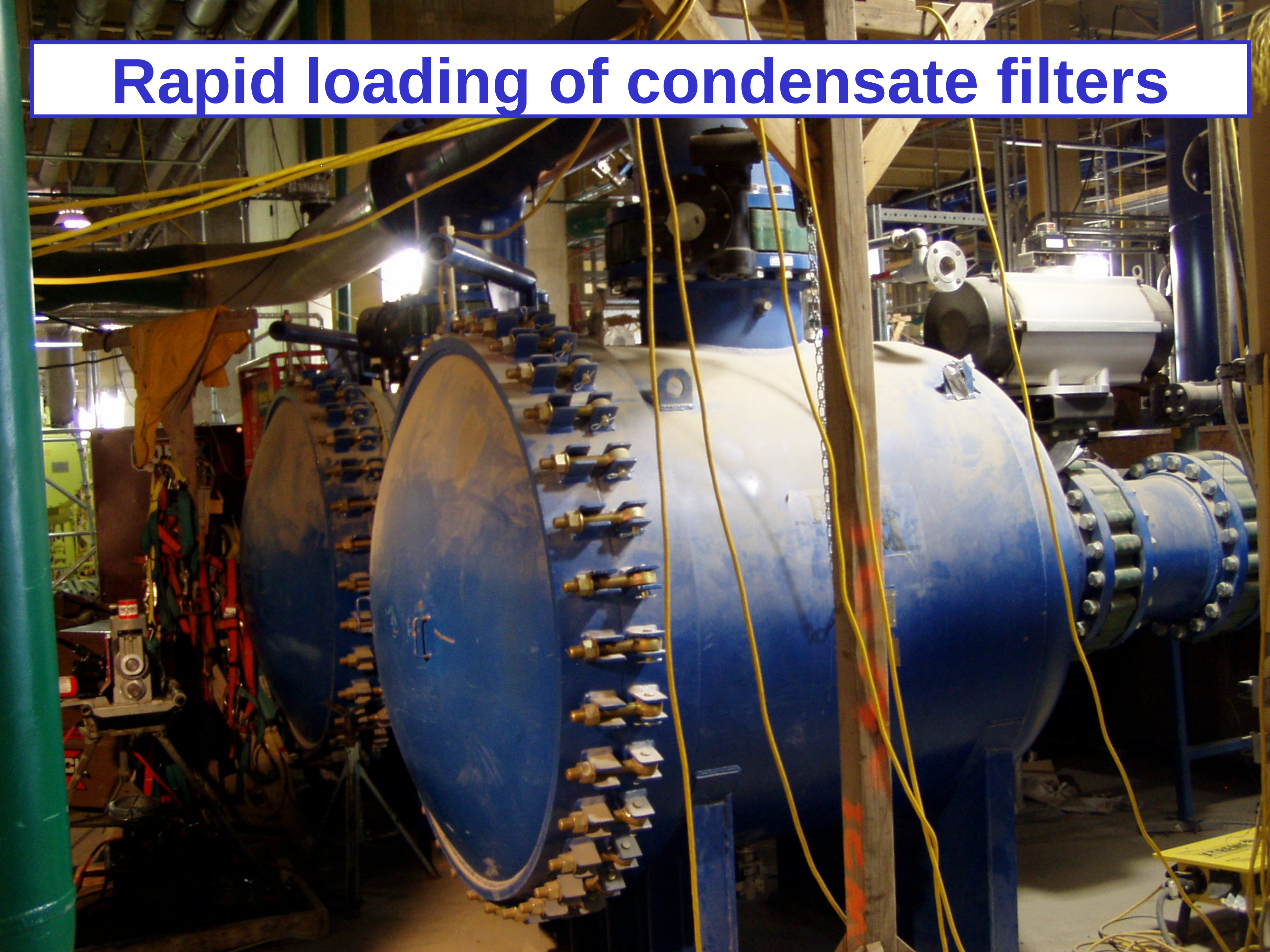




# Consequences of particulate transport

- steam generating tube chemical cleans
- steam generating tube failures
- frequent filter element replacement
  (if condensate filter)
- resin contamination / difficult regeneration
  (if condensate polisher)

# Rapid loading of condensate filters



# Rapid loading of condensate polishers

# Consequences of through-wall leaks

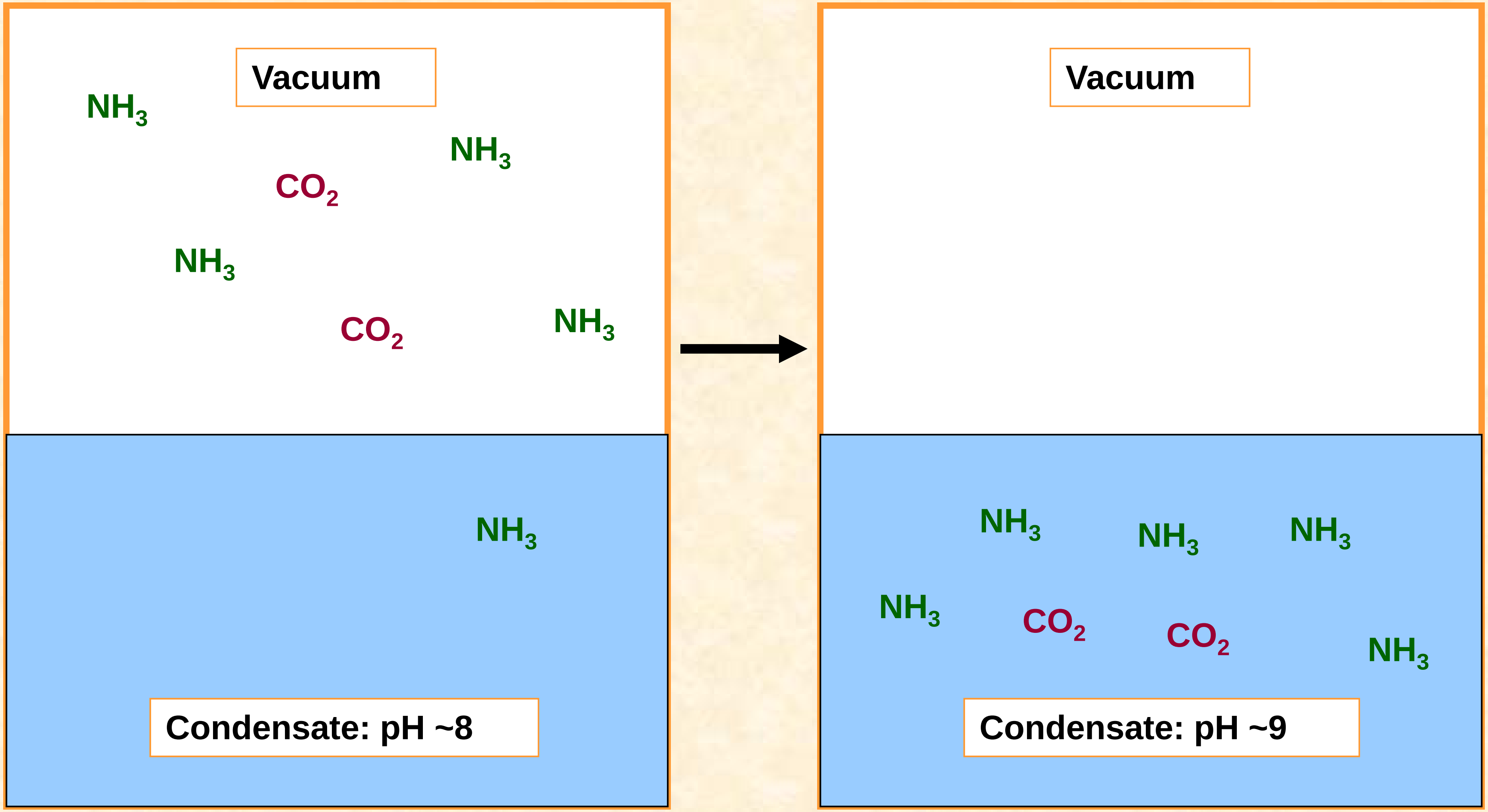
## Air inleakage:

- potential vacuum deterioration (air binding)
- increased steam cycle contamination with oxygen and carbon dioxide
- rapid loading of anion resin (if polisher)

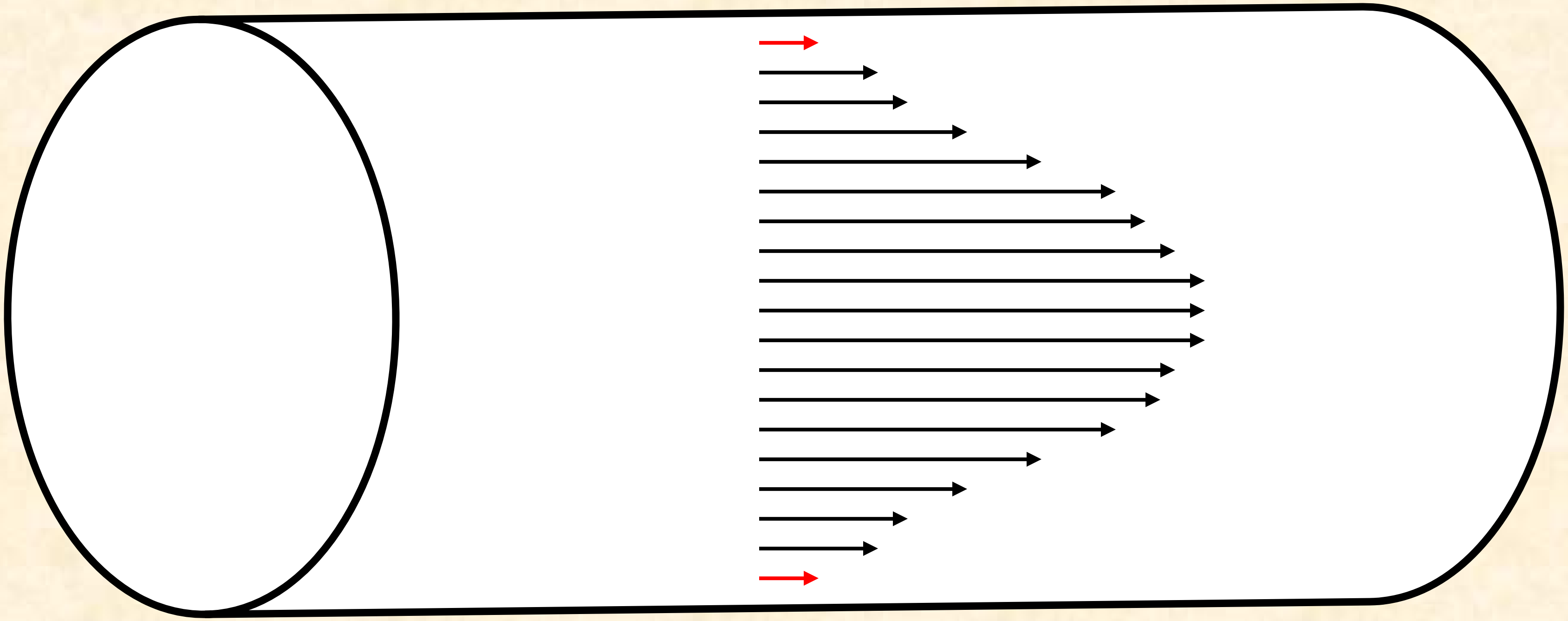
# Iron Corrosion: contributing issues

- early condensate
- steam / condensate velocity
- vacuum conditions

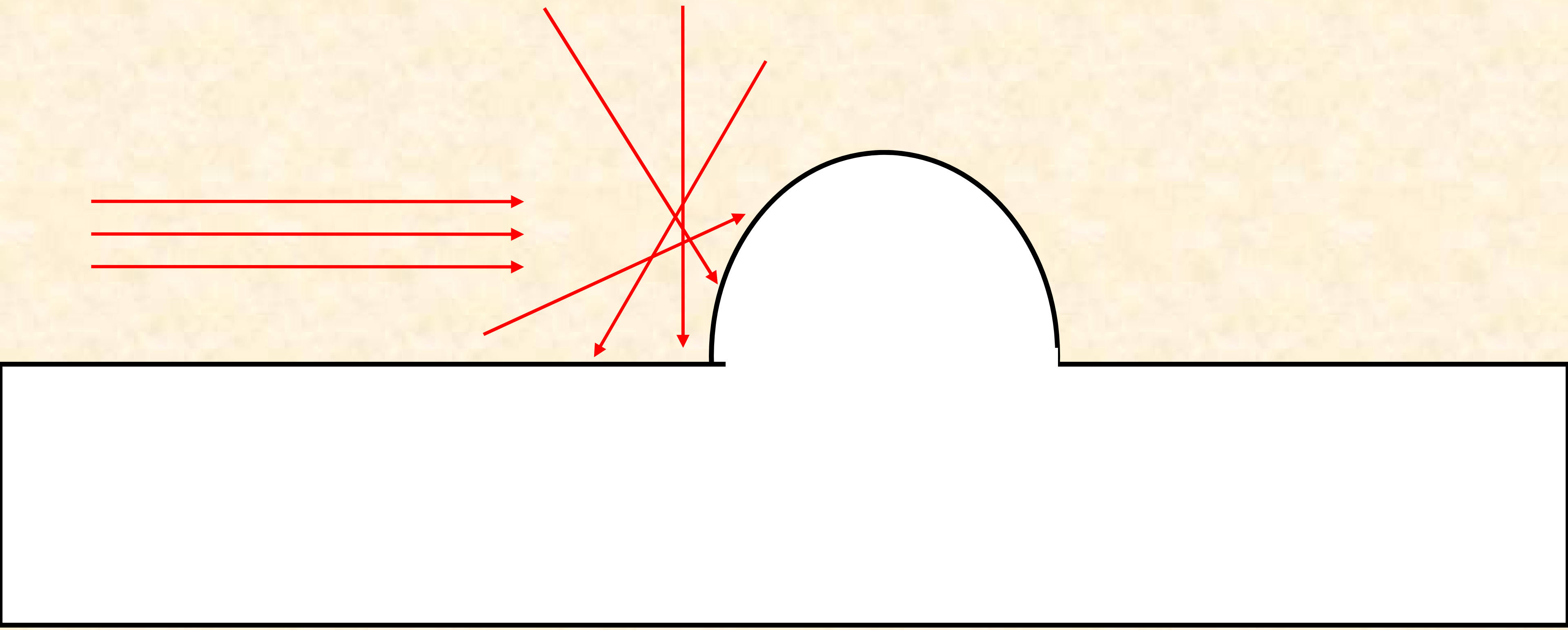
# Early Condensate Environment (steam cycle pH ~9)

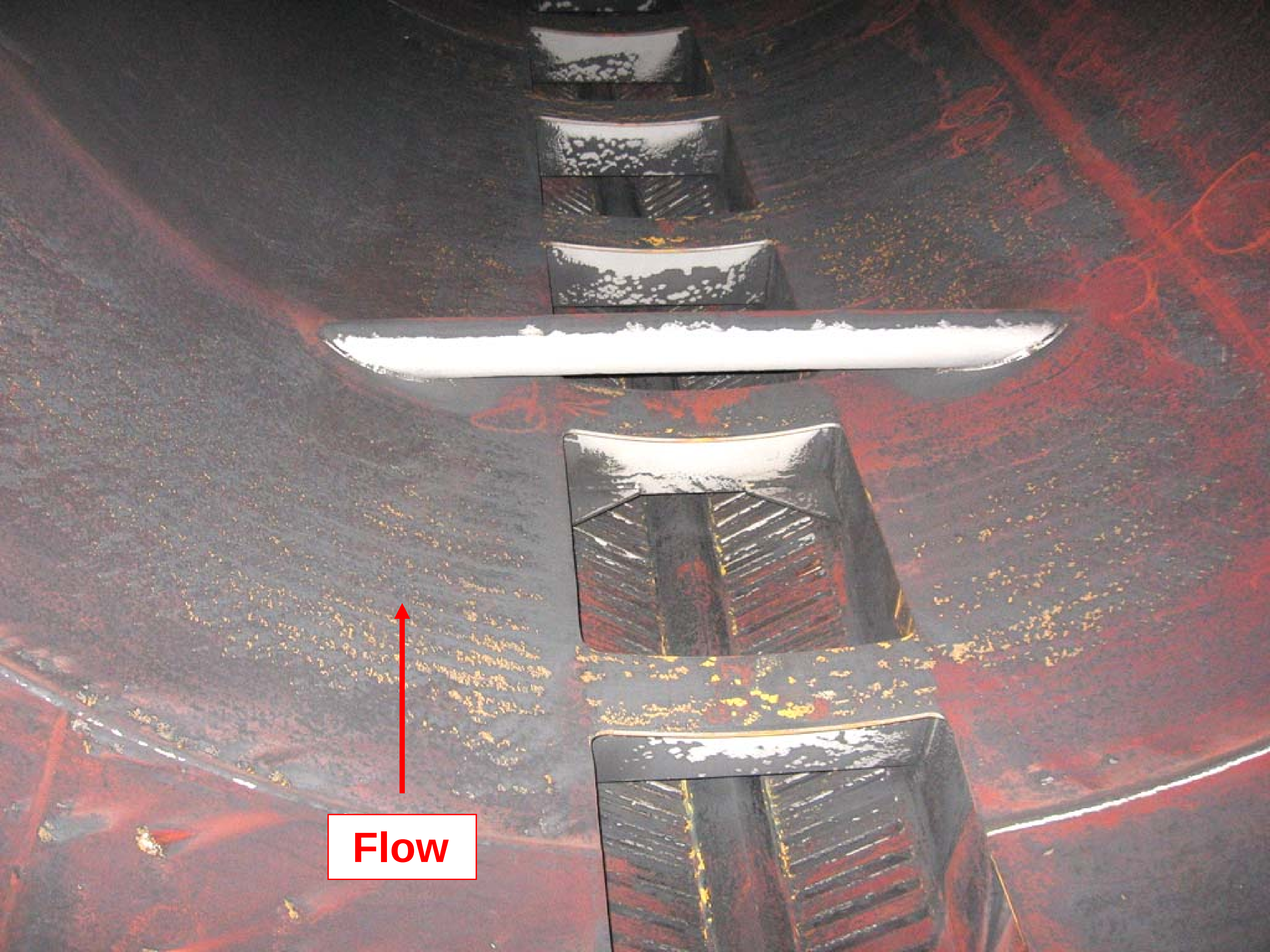


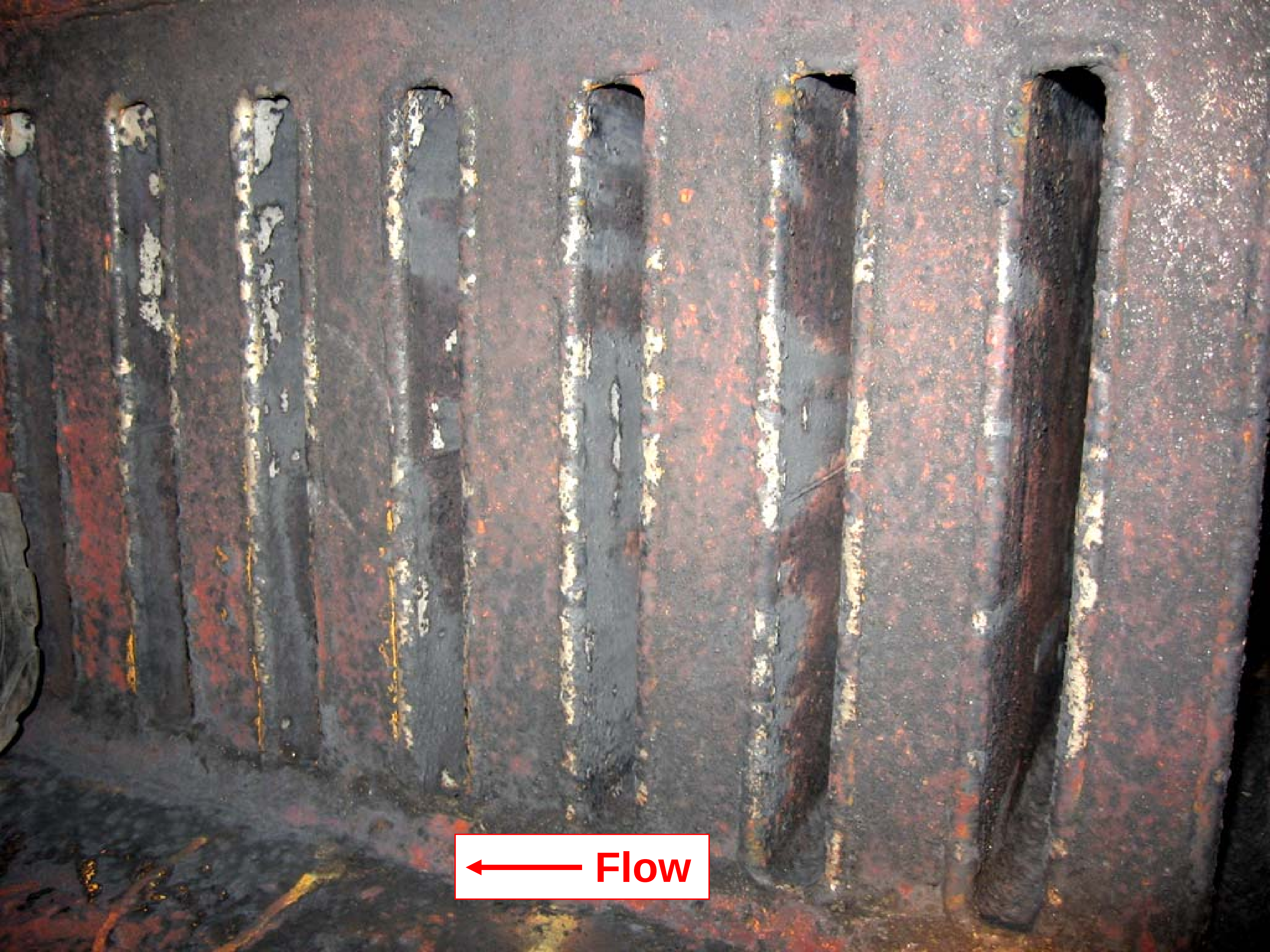
# Steam / Condensate Velocity: laminar flow in pipe (velocity vectors)



# Steam / Condensate Velocity: turbulent flow (velocity vectors)



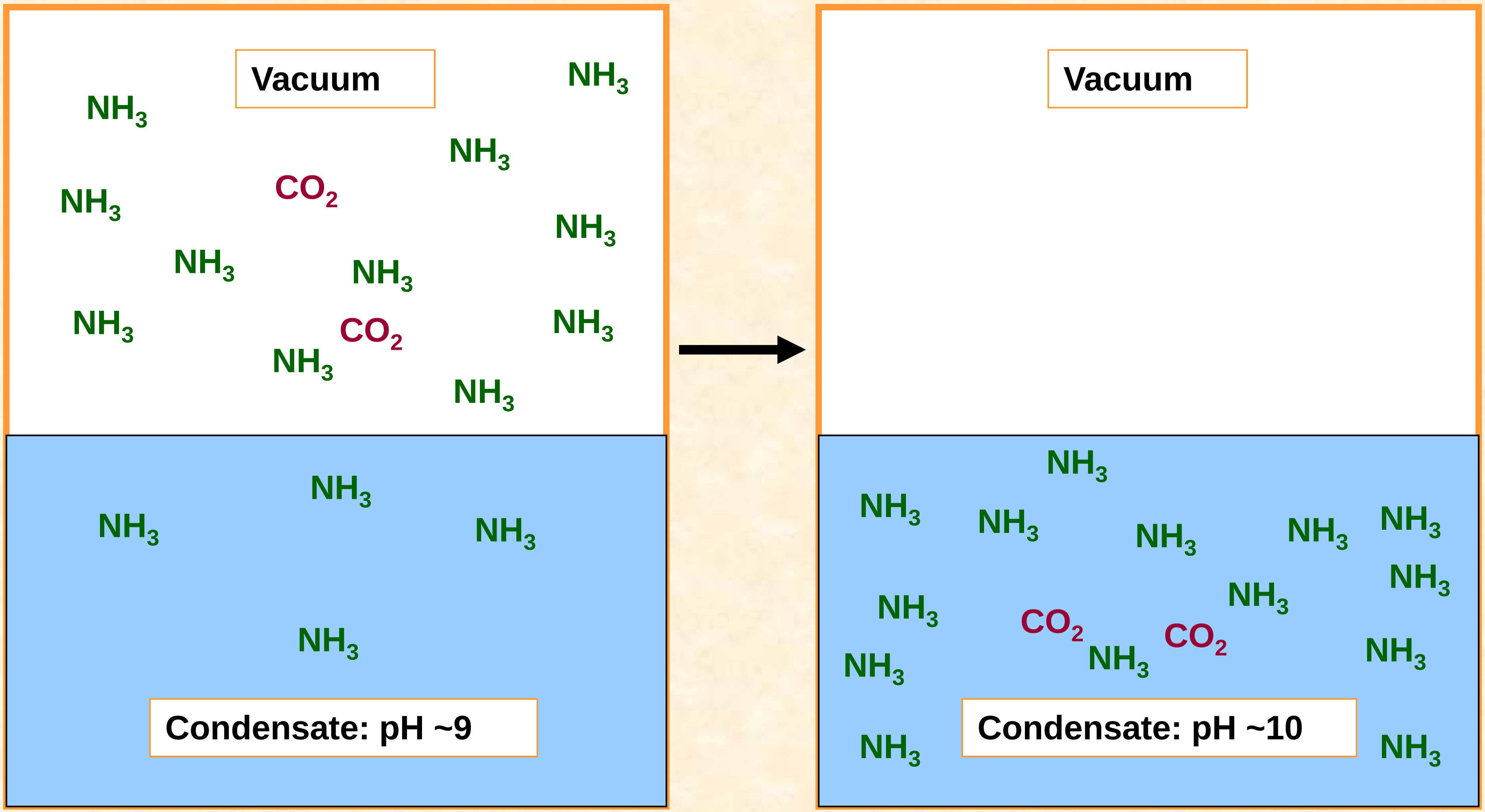

Flow


Flow

# Mechanism of metal loss: 2-phase flow-accelerated corrosion (???)

# Chemistry optimization:
# Elevate pH in early condensate.

# Early Condensate Environment: increased ammonia feed (pH ~10)



**-- or feed alternative less-volatile chemical (e.g. amine)**

***[ decomposition byproducts may generate concerns in some systems ]***

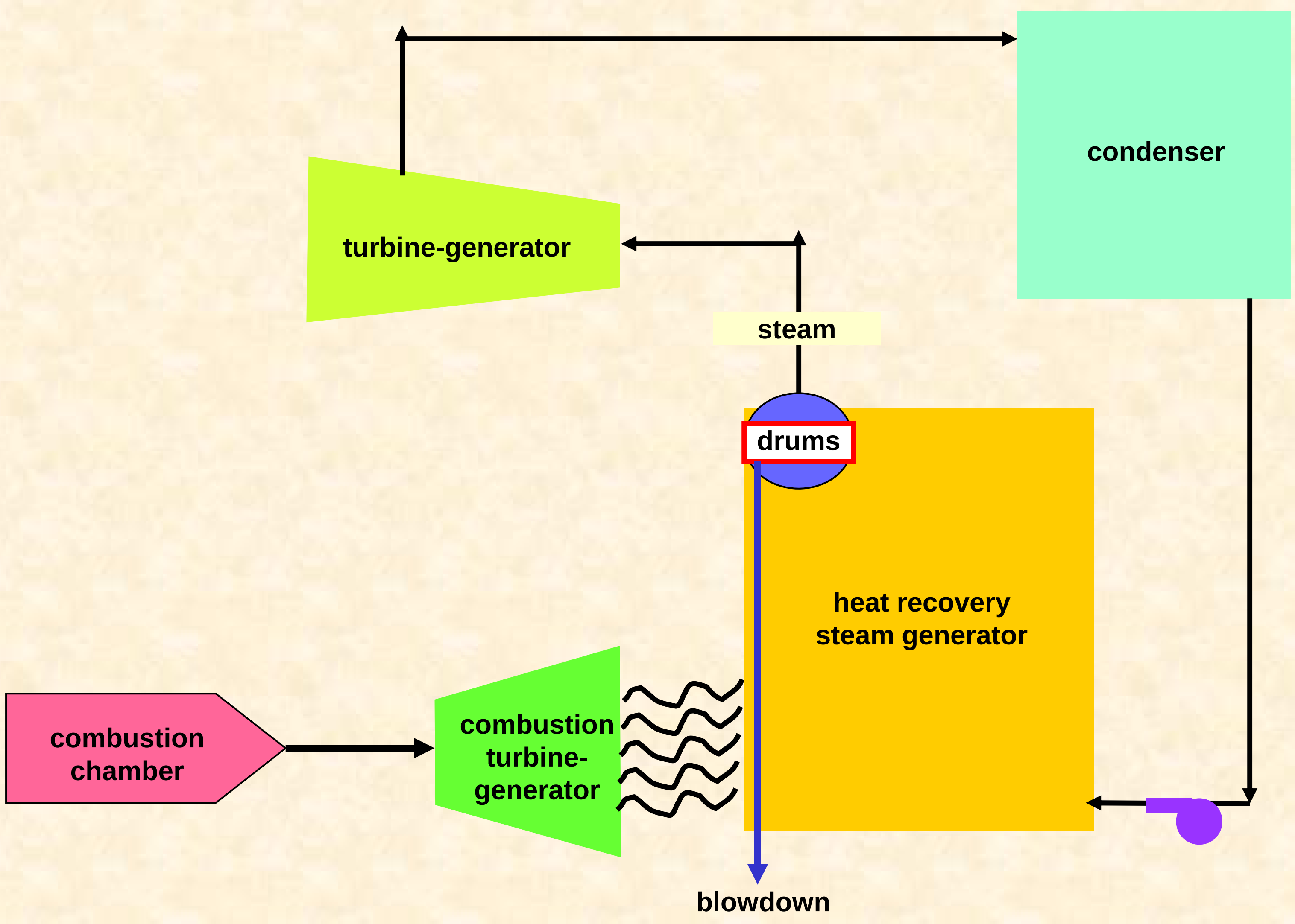
# Other resolution options for iron corrosion:

- alternative material to carbon steel
  - low-alloy or stainless steel
  - inserts / coatings
  - depends on mechanism confirmation
- design to minimize overall velocity and turbulence

# ACC impact depends on unit type & design:

- combined cycle
  - more tolerant of particles and air ingress
  - high pH operation typically simple
- once-through supercritical
  - low tolerance for particles
  - impact of leaks on polisher
  - impact of high pH operation on polisher

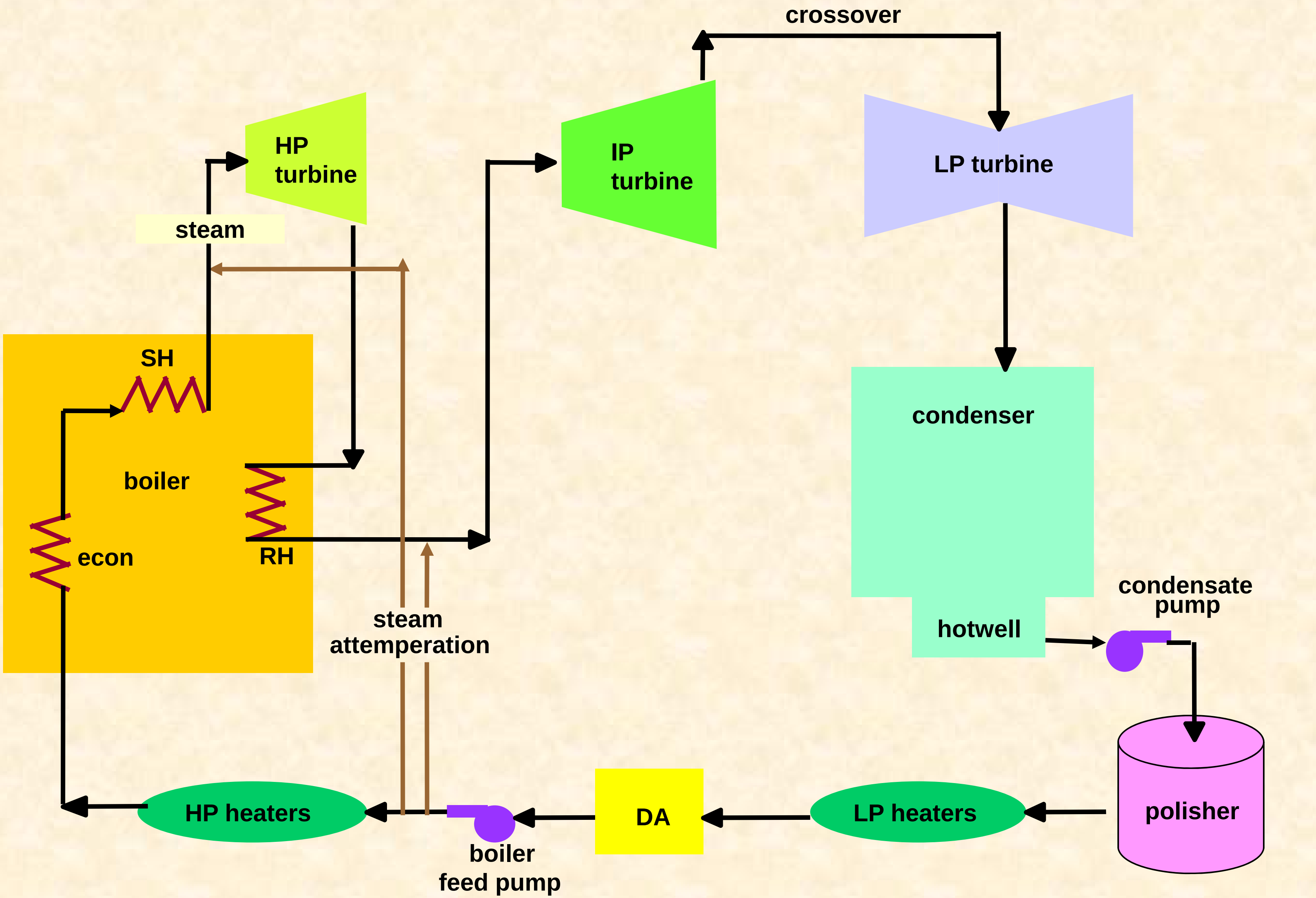
# Combined Cycle Power Plant



# Combined Cycle Power Plants

- steam drums / blowdown for some contaminant removal
- frequent operation in cycling mode
- no polisher or filter typically included

# Supercritical Once-through Power Plant



# Supercritical Once-through Power Plants

- superior water quality required (polisher and condensate filter)
- high pH and air inleakage impacts polisher performance and costs
- normally in baseload operation mode

# ACC Design & Construction: Chemistry Impacts

- **weld debris and fluoride contamination**

# Weld flux debris

# ACC Design & Construction: Chemistry Impacts

- **weld debris and fluoride contamination**
- **iron oxides / miscellaneous crud**

# Iron oxides / miscellaneous construction crud

# ACC Design & Construction: Chemistry Impacts

- weld debris and fluoride contamination
- iron oxides / miscellaneous crud
- improper galvanic tube coating

# Improper Galvanic Tube Coating

# ACC Design & Construction: Chemistry Impacts

- **weld debris and fluoride contamination**
- **iron oxides / miscellaneous crud**
- **improper galvanic tube coating**
- **cleanup for initial unit startup**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# Initial Operation: System Cleanup

NO: P347

# ACC Design & Construction: Chemistry Impacts

- weld debris and fluoride contamination
- iron oxides / miscellaneous crud
- improper galvanic tube coating
- cleanup for initial unit startup
- upper duct access for future inspections

# Ideal Upper Duct Access

# Non-Ideal Upper Duct Access

# ACC Design & Construction: Chemistry Impacts

- weld debris and fluoride contamination
- iron oxides / miscellaneous crud
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- upper duct access for future inspections
- condensate deaerator

# Condensate Deaerator

# Condensate Deaerator

# ACC Design & Construction: Chemistry Impacts

- weld debris and fluoride contamination
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- improper galvanic tube coating
- cleanup for initial unit startup
- upper duct access for future inspections
- condensate deaerator
- upper duct isolation

# Upper Duct Isolation

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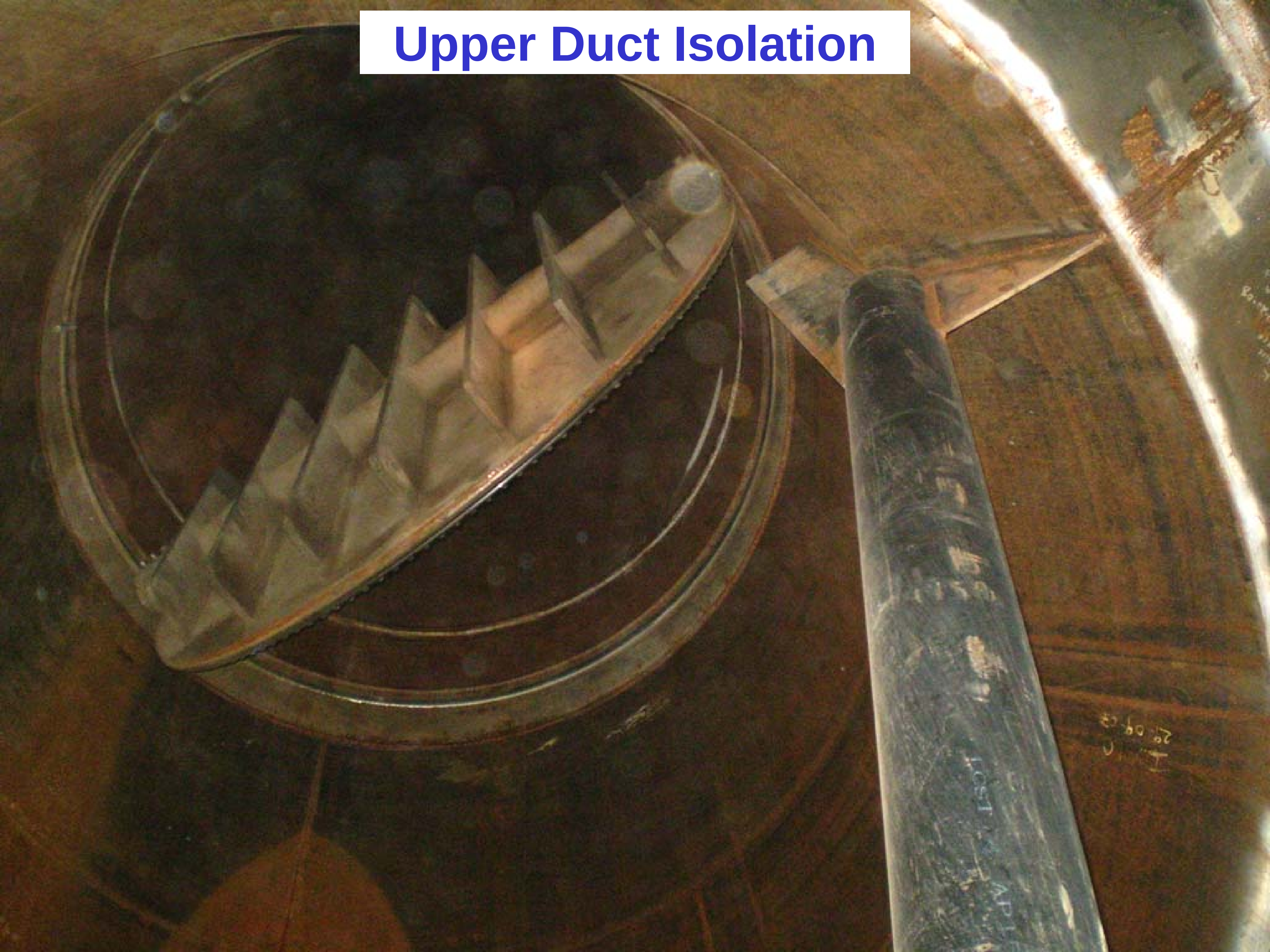

# Guidelines for Off-Line Inspection of Air Cooled Condensers

**- document through the PowerPlant & Environmental Chemistry research subcommittee of ASME**

# Air-Cooled Condenser Interest Group

**- email communications & discussions**

# Conclusions

**Steam Cycle Chemistry is an important factor to be considered in the design and operation of power plants with air-cooled condensers.**