INSPECTION OF RECOVERY BOILERS

W. B. A. (Sandy) Sharp

SharpConsultant,
Columbia, Maryland, U.S.A.

TAPPI Kraft Recovery Short Course
St. Petersburg, Florida, January 7-10, 2008

OUTLINE

- Purpose of inspections
- Inspection methods
- Scope and frequency of inspections

PURPOSE OF INSPECTIONS

- Verify that critical control and safety systems are operating properly
  - ESP test
  - Drum level and low solids trip tests
  - Safety valve tests
  - Instrument function tests
  - Instrument calibration tests
- Verify integrity of pressure parts and evaluate needs for maintenance and/or repair

TYPES OF INSPECTION

- Routine
  - e.g. walkdowns
- Scheduled
  - Major inspections at planned shutdowns
- Opportunistic
  - When boiler becomes available for inspection for other reasons

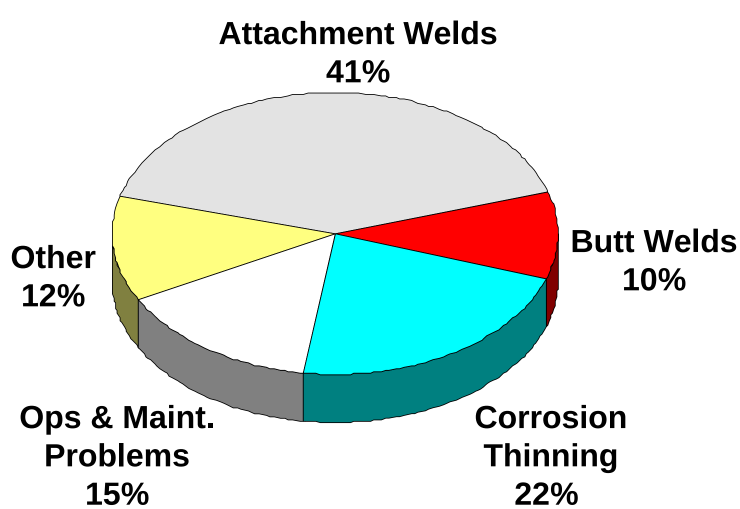
AUDIT PROGRAMS USEFUL TO EVALUATE PERFORMANCE

- Operational performance
- Personnel organizations, progression, training
- Operator procedure checklists
- Boiler and auxiliary system inspections
- Corrosion inspections
- Rectification of non-compliant items
- Audit scope needs regular review

WHY DO WE NEED THESE EXPENSIVE CORROSION INSPECTIONS?

- Must prevent critical leaks
- Scheduled repairs much less expensive than unscheduled
- Cannot predict corrosion rates from boiler operation parameters

CAUSES OF CRITICAL LEAKS



INSPECTION METHODS (1)

- Inspect visually
  - To identify potential problems
- Measure tube thickness
  - To detect thinning problems
- Find fireside cracks
  - That could propagate into leaks
- Find waterside fissures
  - That could propagate into leaks
- Evaluate waterside deposits
  - That could cause overheating

INSPECTION METHODS (2)

- Visual inspection (every scheduled shutdown)
  - by plant workers
  - by outside experts
  - to focus NDT
  - particularly important with composite tubes – every port, every spout, every outage

  - Don't rely on journeyman NDT technicians to make visual inspections

INSPECTION METHODS (3)

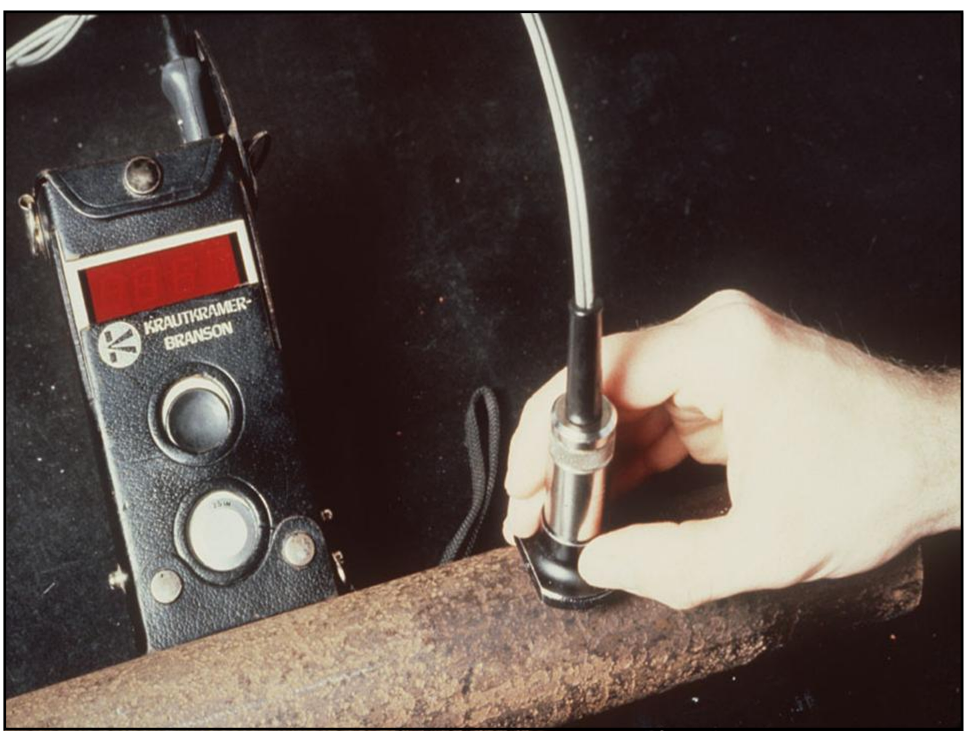
- Measuring tube wall thickness (every scheduled shutdown)
  - Carbon steel tubes (total wall)
    - digital UT
    - oscilloscope UT
    - internal eddy current or UT in gen. bank tubes
    - automated UT for near-drum scanning
  - Composite tubes (protective stainless layer)
    - magnetic lift-off gauge
    - eddy current instrument
    - measure only at air ports, smelt spouts, smelt line, or if DWD very high

INSPECTION METHODS (4)

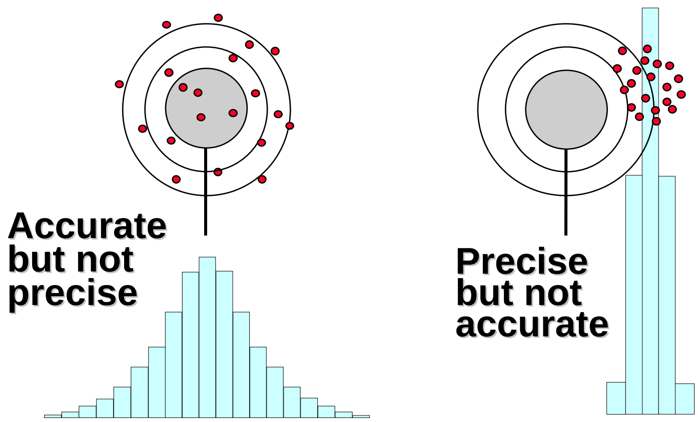
- Look for fireside cracks in areas subject to thermal shock, esp. on composite tubes, with PT
  - Surface preparation is critical (TIP 0402-30)
  - Measure crack depth by exploratory grinding (or shear wave UT)
  - Greater risks in air port tubes than in floor tubes
- Look for waterside SAC in susceptible areas with RT
  - Beam must aim down, not across, fissures
- Analyze waterside deposits

INTERPRETING INSPECTION DATA

- You will not find critical defects unless you look where they are and use a method that can find them
- Judge fitness for service (consequences of discovered defects) using jurisdictional and insurance rules
  - National Board Inspection Code (ASME in some states) skills in fracture mechanics
  - API/ASME FFS-1


KRAUTKRAMER-
BRANSON

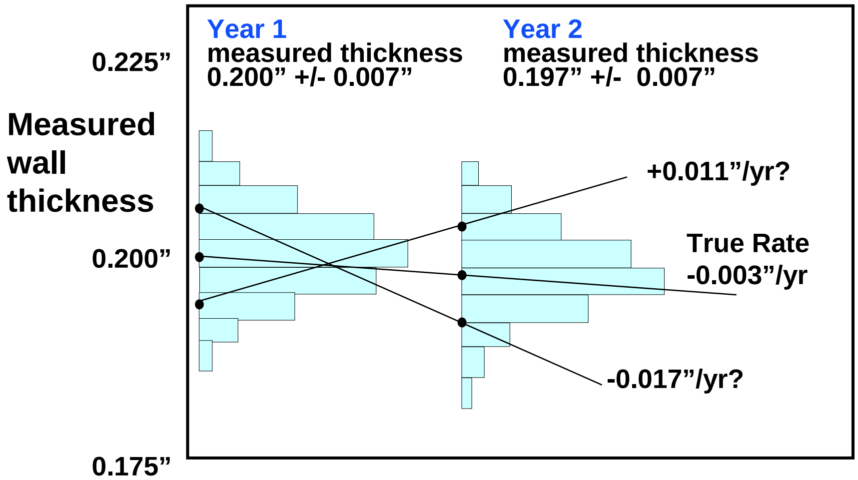
MINIMIZING ERRORS IN TUBE THICKNESS MEASUREMENTS – accuracy and precision



ERRORS IN TUBE THICKNESS MEASUREMENTS

- Standard error in precision 0.005 - 0.007”
- Standard error in accuracy 0.004 - 0.006”
- Combined standard error about 0.007”
  - so check unexpected readings

SINGLE POINT RATE CALCULATIONS ARE NOT ACCURATE



TO MINIMIZE ERRORS IN TUBE THICKNESS MEASUREMENTS

- Use only technicians pre-qualified by TIP 0402-21
- Recalibrate UT instruments every 100 readings, or every 15 minutes - repeat measurements if calibration drifted
- Check unexpected measurements - use different technician, different instrument


1
2
3
4
5
6
7
8


1
2
3

SCOPE AND FREQUENCY OF RECOVERY BOILER INSPECTIONS

- Alert observation during normal operations
- Systematic inspection during outages:
  - Visual inspection and appropriate NDT to find critical defects
  - Thickness measurements to estimate remaining life
- No national standards for scope, methods, frequency
- Develop an individual inspection plan for each boiler (5-year)

SCOPE AND FREQUENCY OF RECOVERY BOILER INSPECTIONS

- Useful documents:
  - AF & PA Recovery Boiler Manual, 1992
  - NACE (composite tubes), 1992
  - TAPPI (UT surveys), TIP 0402-18, 2001 (Technician qualification), TIP 0402-21, 2002
  - ASTM E543 (qualification of NDT contractors)
  - ASNT TC-1A, current edition
  - API/ASME FFS-1 Fitness-for-Service code (2007)

ESTABLISHING INSPECTION SCOPE AND FREQUENCY

- Three approaches have been taken:
  1. Thickness measurements at predetermined grid locations
  2. Thickness measurements based on risk of critical leaks
  3. Visual observations, damage-appropriate NDT and corrosion rate calculations

1. PREDETERMINED GRID LOCATIONS

- No established standards for grid size or frequency
  - wide diversity in practice
- Increasing number of thickness readings generally does not increase probability of detecting critical flaws
- Tailor inspection plans according to
  - historical behavior this unit
  - Problems found in similar boilers

1. PREDETERMINED GRID LOCATIONS

- Use grid readings to:
  - estimate average corrosion rates
  - estimate remaining life
  - “flag” thinned areas
- Supplement grid readings with smaller grids or scanning:
  - in areas known to be critical
  - in areas found to be thin
- Calculate number of readings required to establish thinning rate in different areas of the boiler

1. PREDETERMINED GRID LOCATIONS

- Remember grid methods will <u>not</u> detect:
  - fireside cracking of composite tubes
  - air port balding of composite tubes
  - thinning caused by sootblowers
  - near-drum thinning of generating bank tubes
  - fireside cracking at attachment welds and at headers

1. PREDETERMINED GRID LOCATIONS

- Grid methods will also not detect:
  - thinning next to tube-to-tube membrane
  - localized thinning at ports and at the smelt line
  - cold-side corrosion of non-membrane water wall tubes
  - waterside corrosion fatigue cracking (SAC)
  - excessive waterside deposits

2. RISK OF CRITICAL LEAKS

- 32% in lower water wall,
  - + 8% in floor + 6% at spouts
- 15% in upper water wall
- 12% in furnace screen
- 18% in generating bank

2. RISK OF CRITICAL LEAKS

- Relative grid sizes:

Floor	4 x 4
Lower water wall	1 x 1
Upper water wall	2 x 2
Generating bank	2 x 2
Roof	2 ¼ x 2 ¼
Furnace screen	2 2/3 x 2 2/3
Air port tubes	scan 100%

- Why is this a bad approach?

2. RISK OF CRITICAL LEAKS

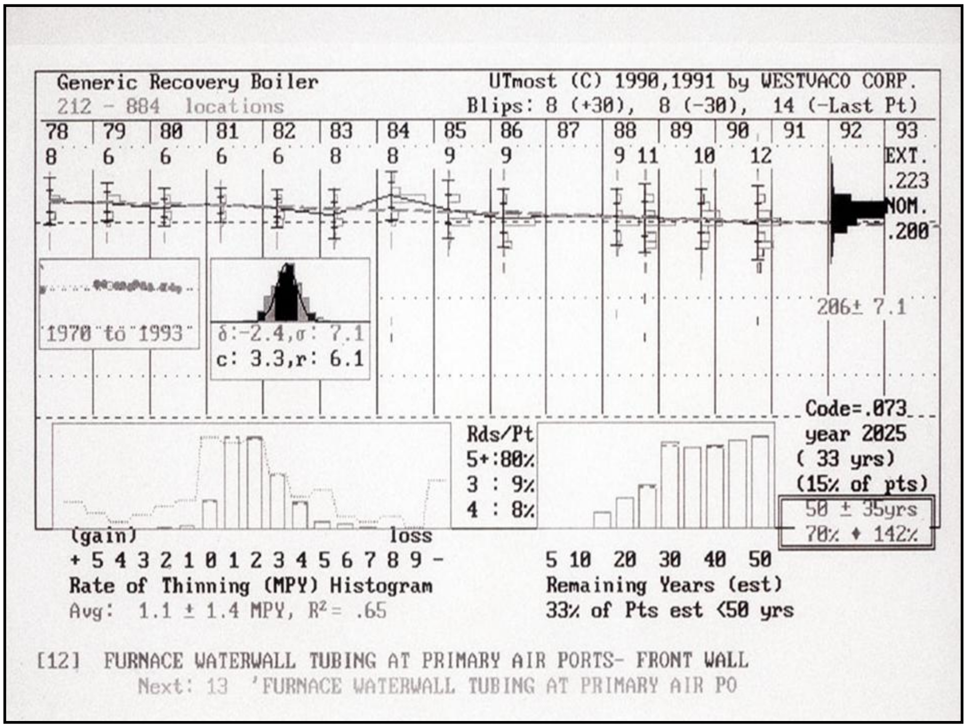
- Critical leaks show what careless inspectors have missed, not what careful inspectors have found
- So, since most leaks occur at defects created when the boiler was built, use critical leak data for planning QA programs rather than for planning inspections

3. CORROSION RATES

- Establish scope and frequency of grid measurements to obtain statistically significant estimates of corrosion rate in each part of the boiler
- To estimate rates with fewest measurements, measure thickness at same exact locations
- Typically at least 100 measurements must be repeated in each part of the boiler on at least 4 occasions

3. CORROSION RATES

- Computer generated thickness maps show patterns of thinning useful to refine grid sizes
- Computer programs can:
  - calculate thinning rates
  - estimate remaining life
  - indicate the probable accuracy of these predictions
- Don't try to calculate corrosion rates at individual points

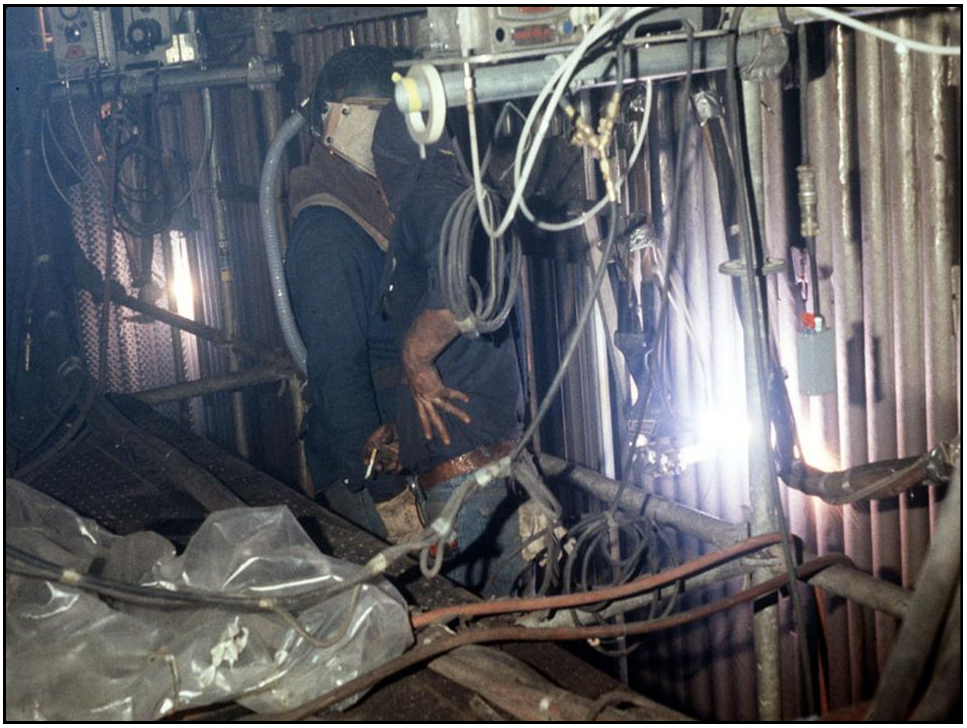

Generic Recovery Boiler
212 - 884 locations
UTmost (C) 1990,1991 by WESTVACO CORP.
Blips: 8 (+30), 8 (-30), 14 (-Last Pt)
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93
8 6 6 6 6 8 8 9 9 9 11 10 12
EXT.
.223
NOM.
.200
1970 to 1993
δ: -2.4, σ: 7.1
c: 3.3, r: 6.1
206 ± 7.1
Code=.073
year 2025
(33 yrs)
(15% of pts)
50 ± 35yrs
70% ♦ 142%
Rds/Pt
5+:80%
3 : 9%
4 : 8%
(gain)
loss
+ 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 -
Rate of Thinning (MPY) Histogram
Avg: 1.1 ± 1.4 MPY, R² = .65
5 10 20 30 40 50
Remaining Years (est)
33% of Pts est <50 yrs
[12] FURNACE WATERWALL TUBING AT PRIMARY AIR PORTS- FRONT WALL
Next: 13 'FURNACE WATERWALL TUBING AT PRIMARY AIR PO

SCOPE AND FREQUENCY RECOMMENDATIONS

- Use expert visual inspectors to seek critical flaws
- Use grid measurements to estimate corrosion rates
- Do additional NDT in areas:
  - of concern from previous inspections
  - of concern to current inspectors
  - of concern because of findings elsewhere in the industry

KEYS TO SAFE, LOW MAINTENANCE OPERATION

- Quality assurance to avoid building in defects during design and construction
- Careful operation by well-trained operators
- Regular, systematic, and well-documented inspection
- Planners and Inspectors aware of new inspection technology and of problems found elsewhere (BLRBAC, TAPPI, NACE)
- Timely maintenance with accountability



CONCLUSIONS

- AF & PA manual contains useful inspection planning checklists
- Tailored NDT plans can find thinning, cracking and internal defects
- Use expert visual inspectors to direct the search for thinnest tubes and critical flaws
- Because of (0.007”) errors in individual thickness readings, use UT data (only) to establish corrosion patterns, project rates and schedule repairs/ rebuilds