Well Integrity Assurance: A Successful Method for External Corrosion and Damage Detection on Outer and Middle Concentric Strings of Casing

SPE no. 108698

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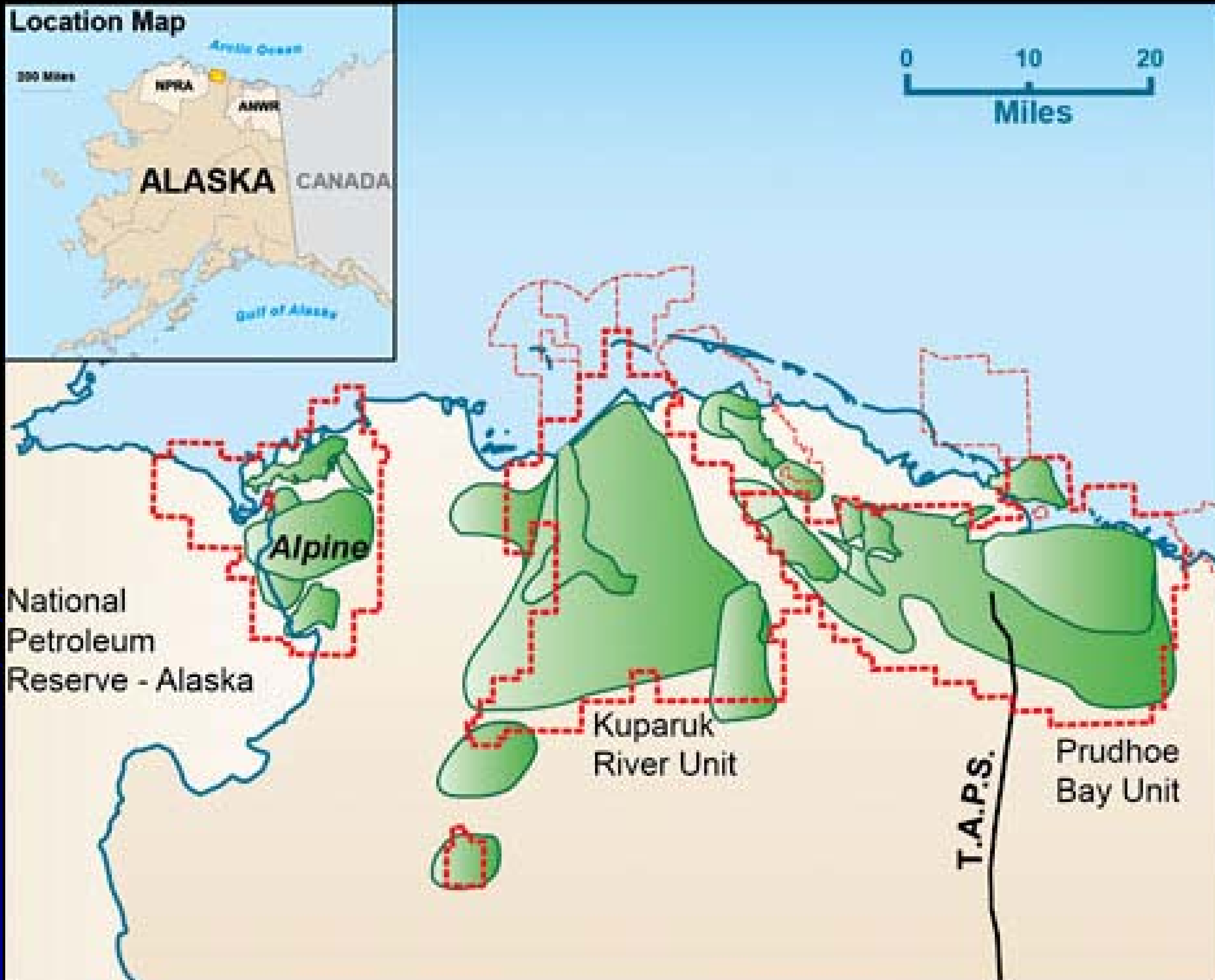
13NOV07



Location Map
Arctic Ocean
NPRA
ANWR
ALASKA
CANADA
Gulf of Alaska
0
10
20
Miles
Alpine
National
Petroleum
Reserve - Alaska
Kuparuk
River Unit
T.A.P.S.
Prudhoe
Bay Unit

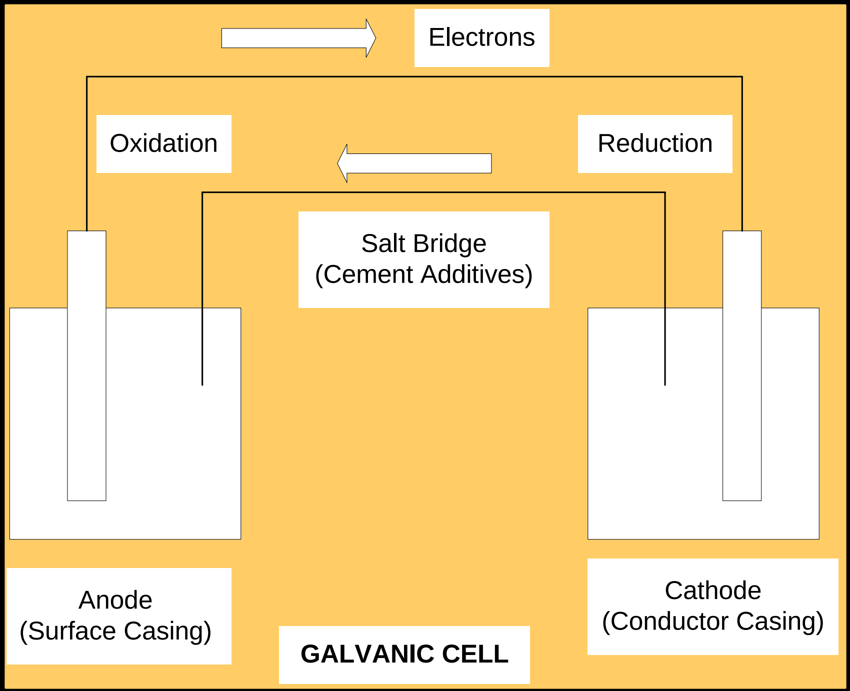
Shallow External Casing Corrosion

- To Initiate Corrosion…
  - Just Add Water
    - Large Water Surface and Open Air Flow Path
    - Re-generates Oxygen Content

Shallow External Casing Corrosion

Galvanic Corrosion

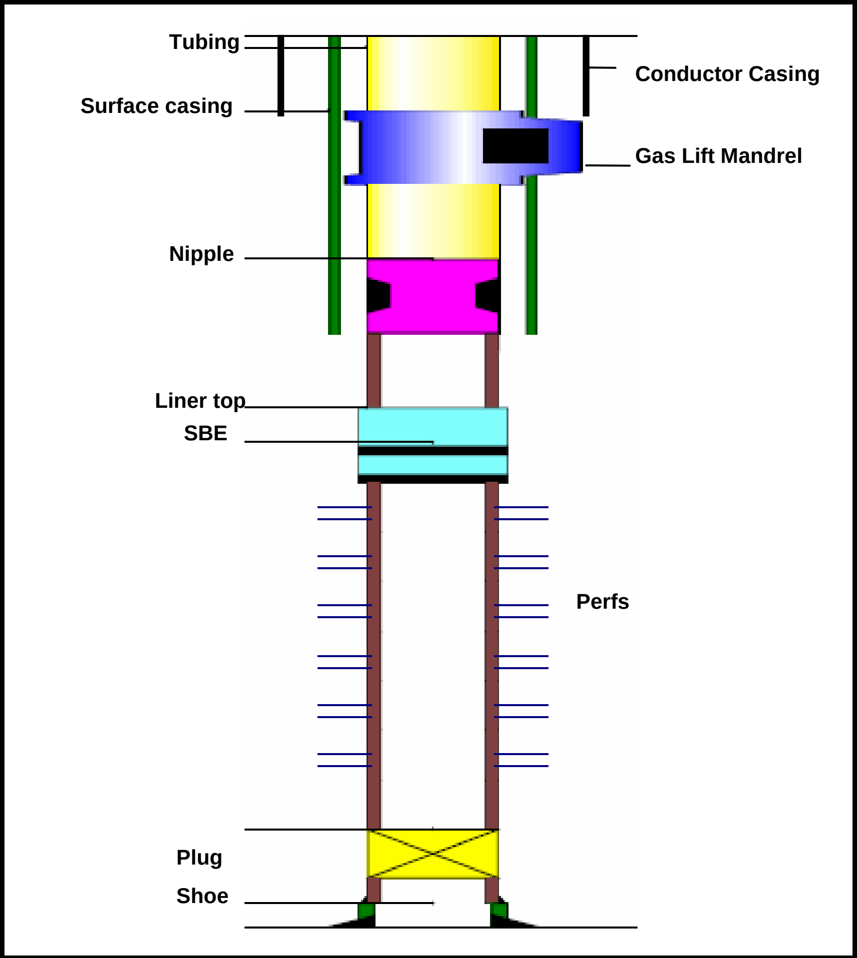
Galvanic cell is created from presence of electrolyte, oxygen and sacrificial anode (surface casing)



- **Heat Increases Corrosion Rate**
  - **Single Casing Completion with Hot Water Injection**
    - **Higher Temperature Gradient = Faster Thermo-Galvanic Corrosion**

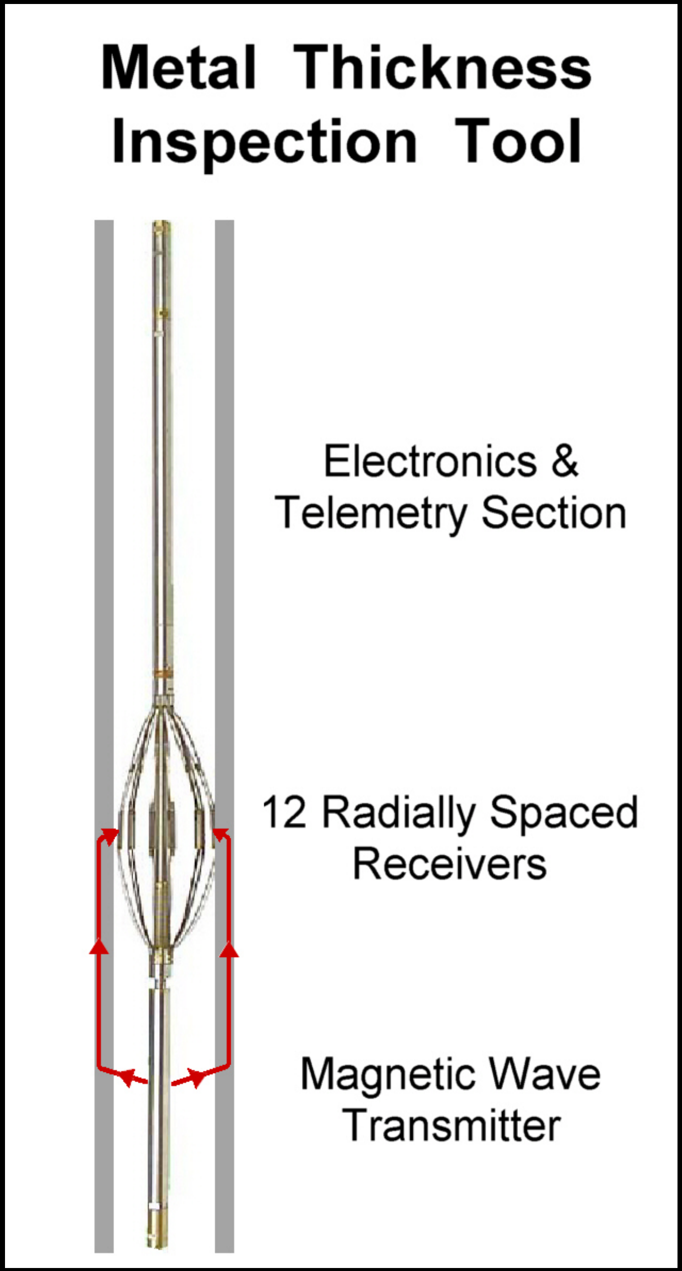
Single Casing Design

- Recent SC failures prompted the search for a method to determine corrosion severity on the middle concentric ring of casing



Tool Description

- Memory Tool
- Generates an alternating magnetic wave
- Wave is detected on one of 12 sensor arrays when it completes its path
- Wave velocity and amplitude is affected by metal thickness
- Sensor next to an area with metal loss receives wave back quicker than area with no metal loss



Tool Development

- Originally developed to assess single tubular applications to provide an absolute remaining wall thickness
  - Useable transmission frequency ranges from 8 to 16 Hz.
  - Higher frequencies provide for greater vertical detail of anomalies, but reduce the overall amount of metal that the signal can effectively travel through
  - Lower frequencies can effectively travel through higher metal volumes, but provide less detail of recorded anomalies

Concentric casing applications

- Provide a Qualitative metal loss from all 3 strings of casing
- For intervals < 500’ complete 3 passes using lower frequency spread 8, 10, and 12 Hz.
- Sharper features at higher frequency are most likely inner concentric strings
- Features more prevalent at lower frequency are more likely from outer concentric strings

Logging/Excavation Plan

- Log was run on 7 wells with 3 concentric strings near surface scheduled for excavation repair.

- Compared to results of visual inspection

Comparison of Visual Inspection to Log Results in Well A

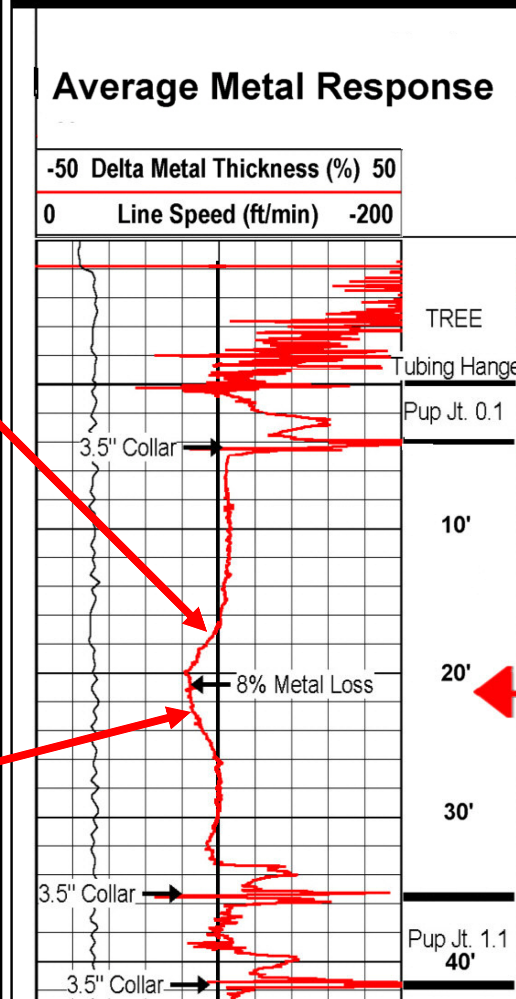
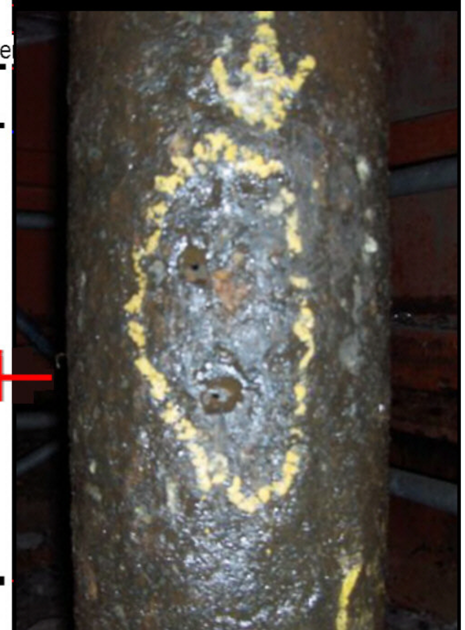
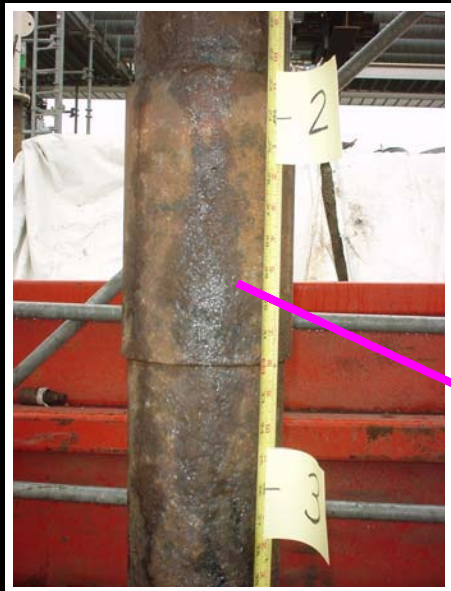
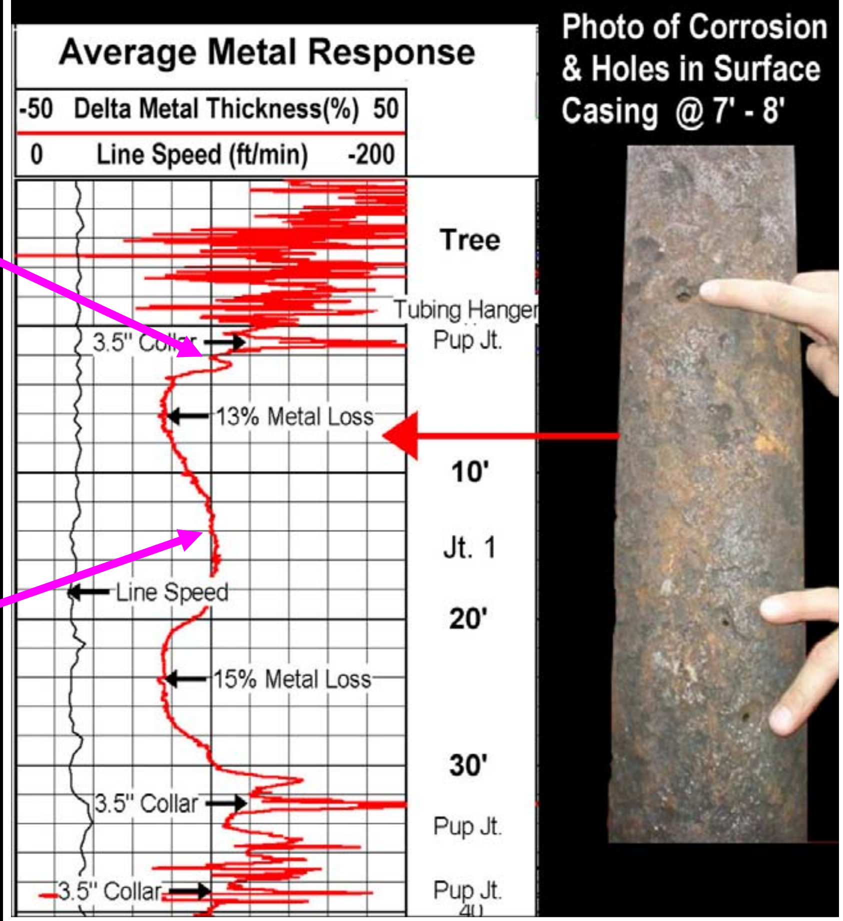


Photo of Corrosion & Holes in Surface Casing @ 21.5'



Comparison of Visual Inspection to Log Results in Well B





Comparison of Visual Inspection to Log Results in Well C

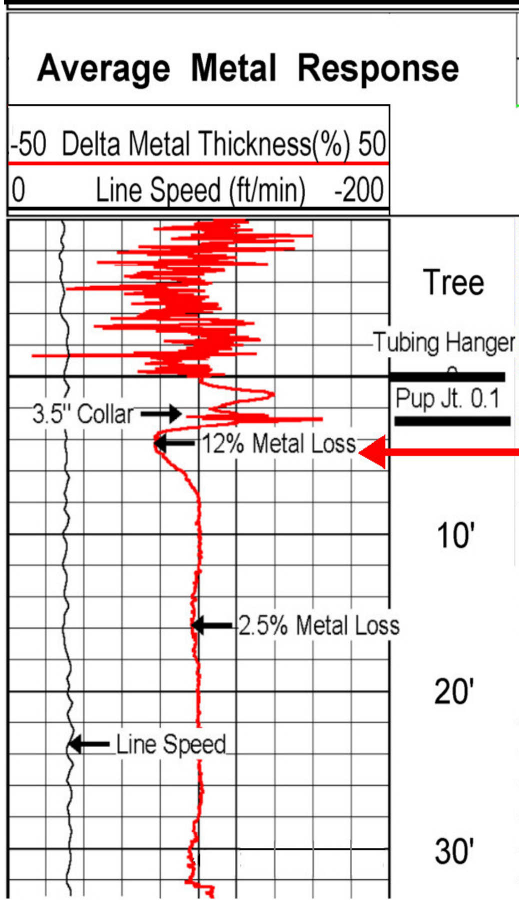


Photo of Corrosion & Crack in Surface Casing @ 5'

Comparison of Visual Inspection to Log Results in Well D

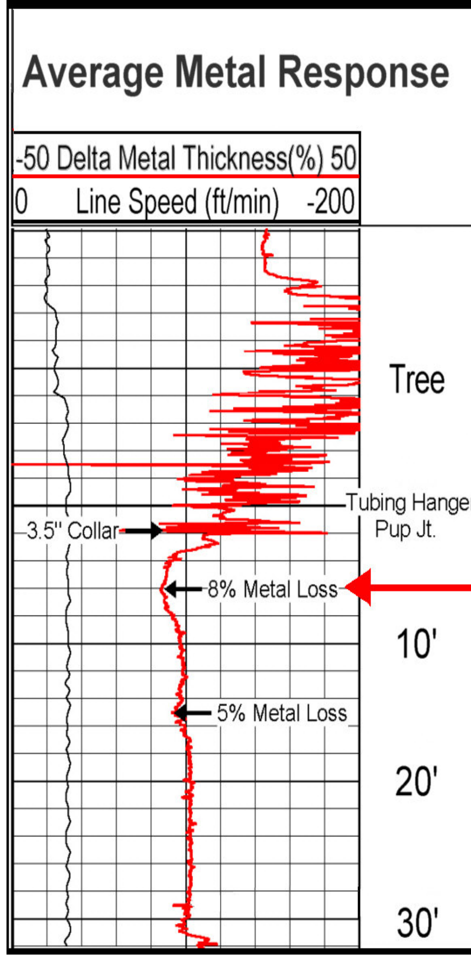


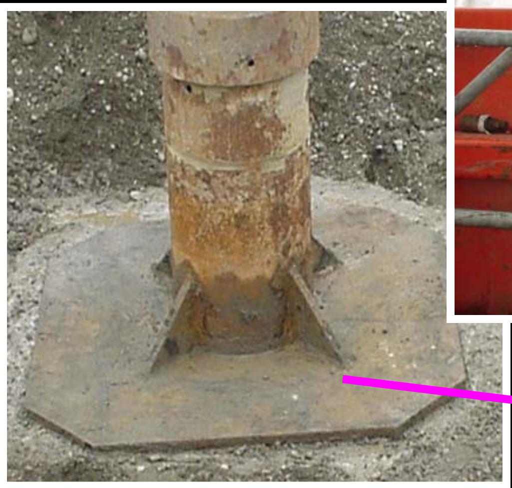
Photo of Corrosion & Hole in Surface Casing @ 6'

Well Information						Log Results			
Well	Reason	TYPE	SC (in.)	CC (in.)	Tubing (in.)	COMMENTS / STATUS	Patch Repair status	Caliper Data	Log vs Visual Correlation
A	Failed	INJ	5.5	16	3.5	8% metal loss from 18-26'	Done	shallow pitting pits up to ~2 % metal loss	Excellent
B	Failed	INJ	5.5	16	3.5	13% metal loss from 3.5-12' 15% metal loss from 18-29'	Done	pits w/ 6% metal loss at 32'	Excellent
C	Failed	INJ	5.5	16	3.5	12% metal loss from 4-8'	Done	shallow pitting up to ~2 % metal loss	Excellent
D	Failed	INJ	5.5	16	3.5	8% metal loss from 4'-10'	Done	no data near surface	Excellent
E	Failed	INJ	5.5	16	3.5	7% metal loss from 4-10'	Done	shallow pitting pits ~2 -5% % metal loss	Excellent
F	Failed	INJ	5.5	16	3.5	7% metal loss at 7' 6% metal loss from 10-20' may be tubing damage	Done	shallow pitting up to 4% metal loss	Excellent
G	Failed	INJ	5.5	16	3.5	8% metal loss from 3-10' 13-15% metal loss from 20-40' - some loss may be tubing wall	Done	shallow pitting 2-6% metal loss	Excellent
H	Proactive	Gas Lift	7.625	16	2 .875	2% metal loss from 10-12' Noisy - hard to interpret - may be the 7 5/8" x 2 7/8" combo	Not needed	none	Good
I	Proactive	Jet Pump	7.625	16	3.5	16% metal loss from 0-3' metal loss my be exaggerated by larger size casing or tubing corrosion is also present	Done	none	Good
J	Proactive	INJ	5.5	16	3.5	5% metal loss at 1'	Done	shallow pitting up to ~3% metal loss	Good
K	Proactive	INJ	5.5	13.375	3.5	8% metal loss from 0-2' some wall loss may be tubing	Not needed	shallow pitting up to 4% metal loss	Poor
L	Proactive	INJ	5.5	16	3.5	15% metal loss at 4' Results really hard to read Possible line speed issues	Done	shallow pitting up to ~2 % metal loss	Poor

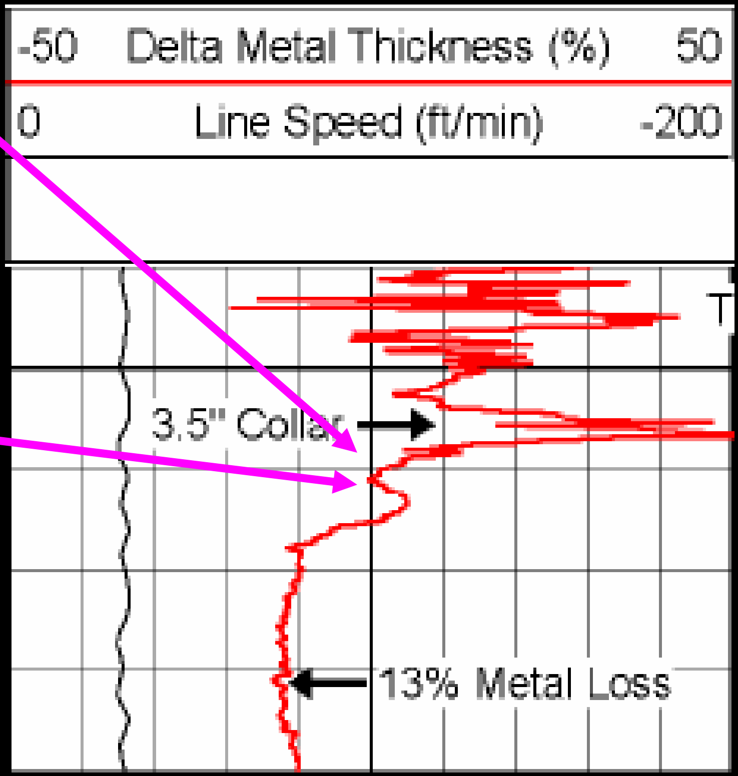
Correlation Confidence

Casing Configurations			Well Statistics		
CC (in.)	SC (in.)	Tubing (in.)	Logs Run	Visually inspected	Correlation confidence
16	8.625	3.5	1		NA
16	7.625	2.875	1	1	Not yet
16	7.625	4.5	4		NA
16	7.625	3.5	2	1	Not yet
16	5.5	3.5	16	9	Yes
13.375	5.5	3.5	1	1	Not yet

Complicating Factors – Physical Issues



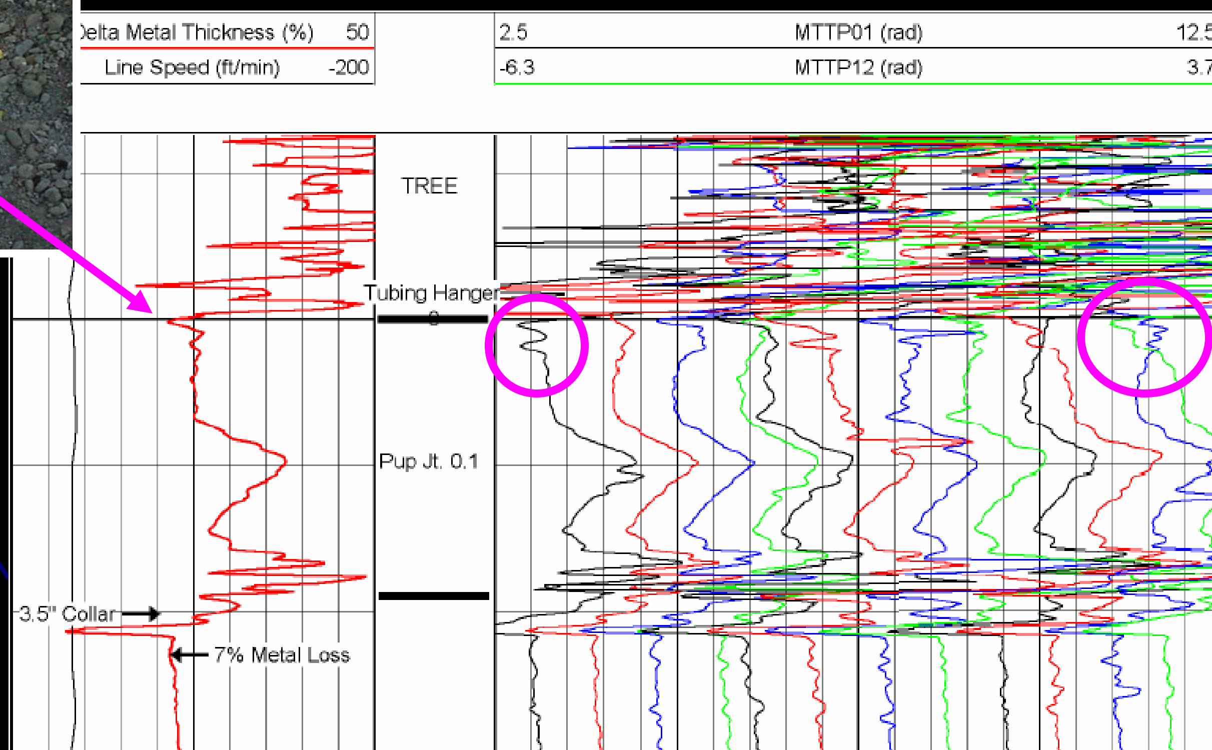
SC casing collar and standing plate are in the same location masking SC damage



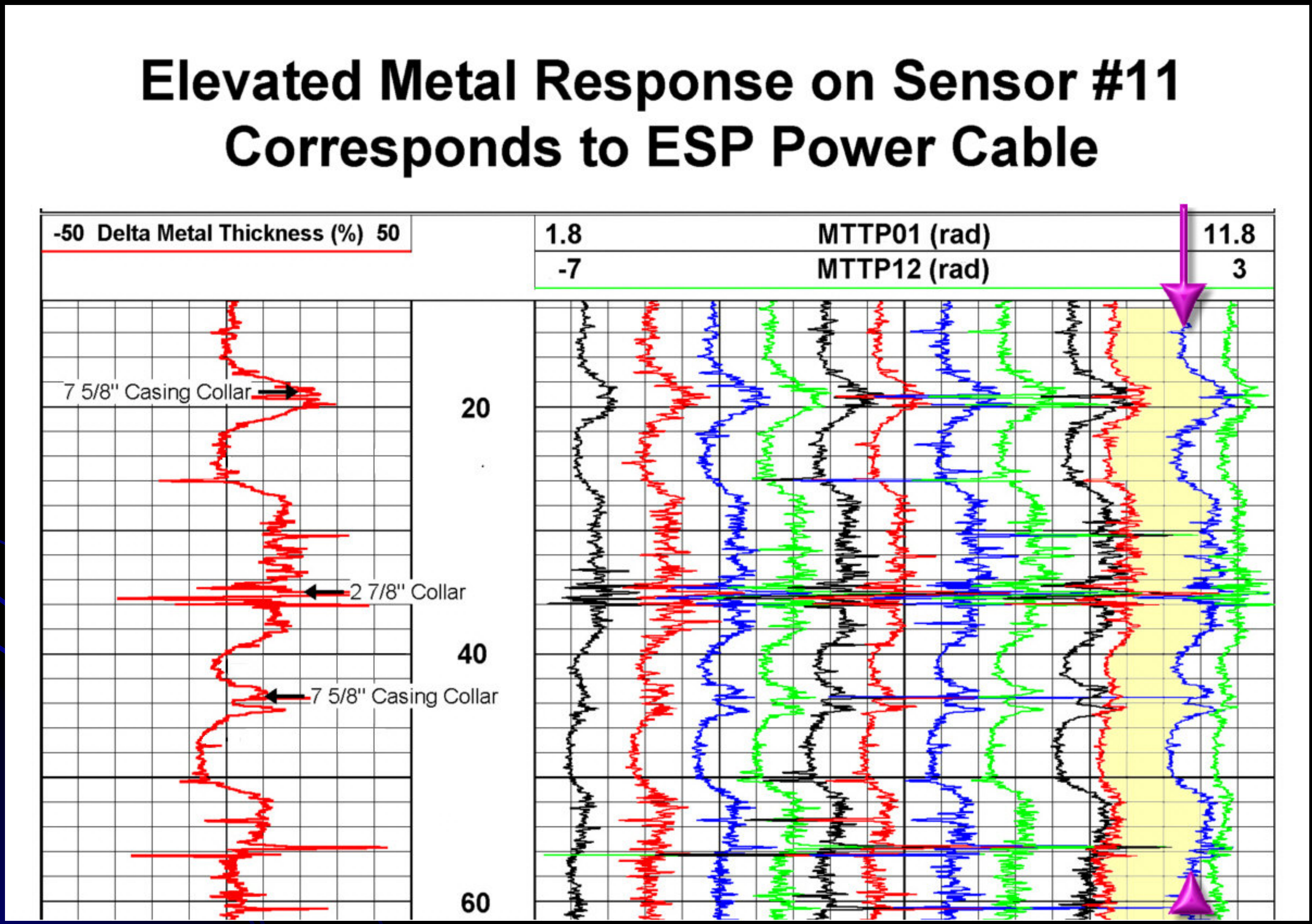
Sharp features are generally the inner most string where more spread out response appears to correlate with middle and outer concentric casing

Complicating Factors – Physical Issues

Cement Circulation ports can be clearly identified on sensors 1 and 12

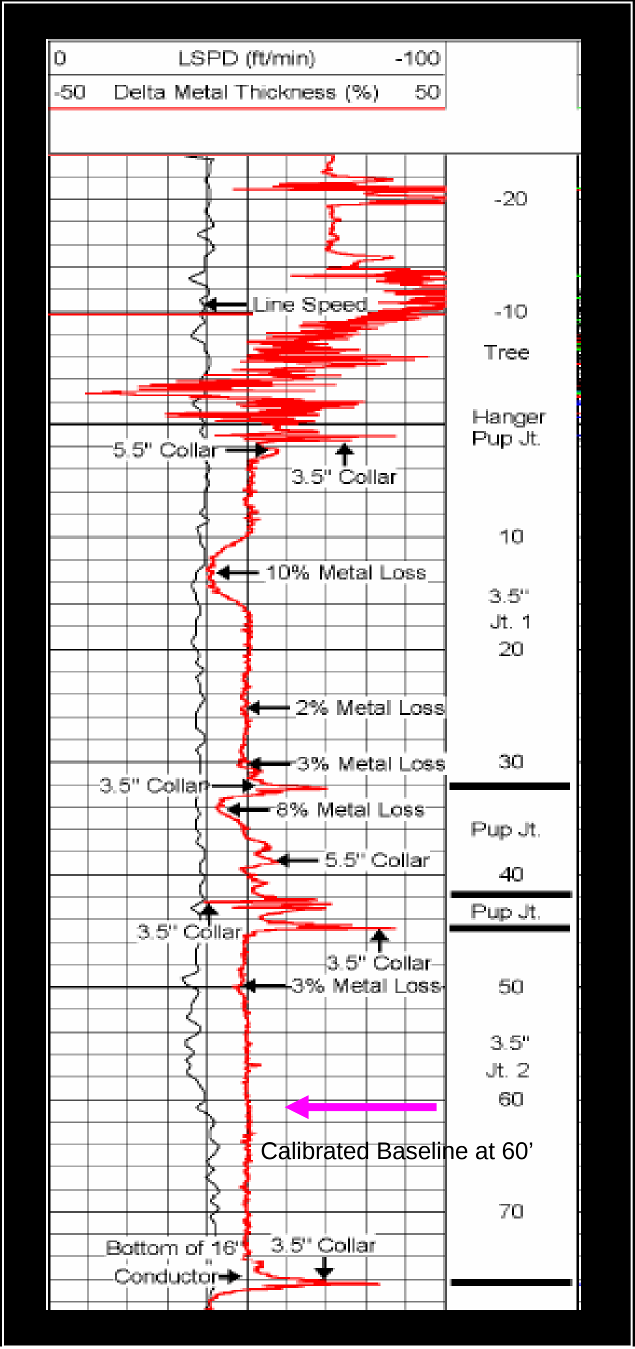


Complicating Factors – Physical Issues

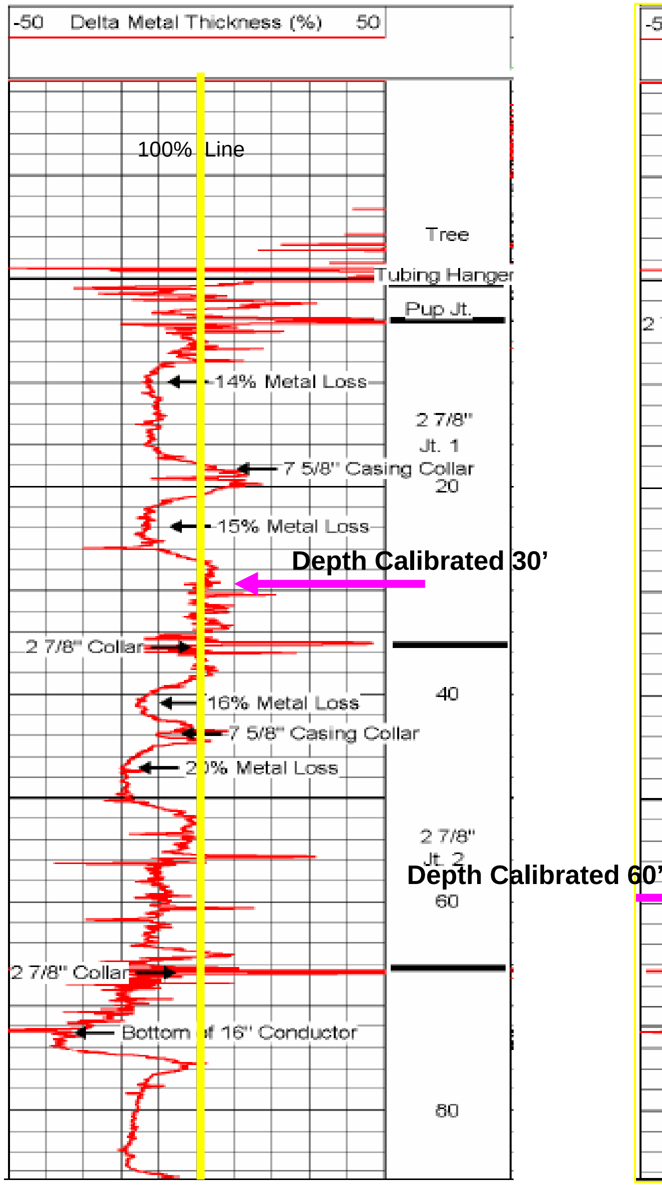


Assumption

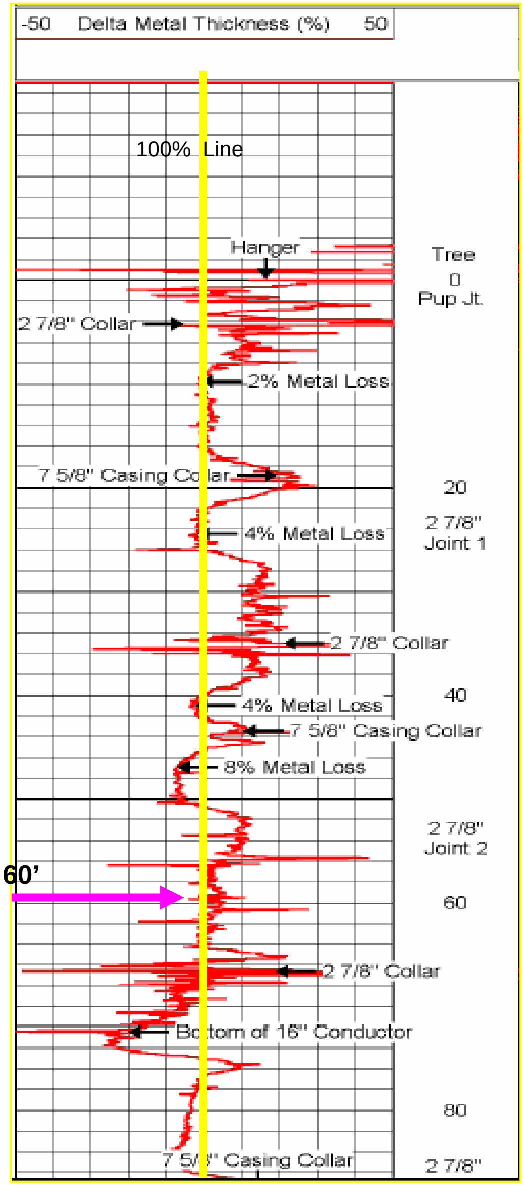
- Baseline area has 100% metal thickness



One Data Set Calibrated at Two Different Depths

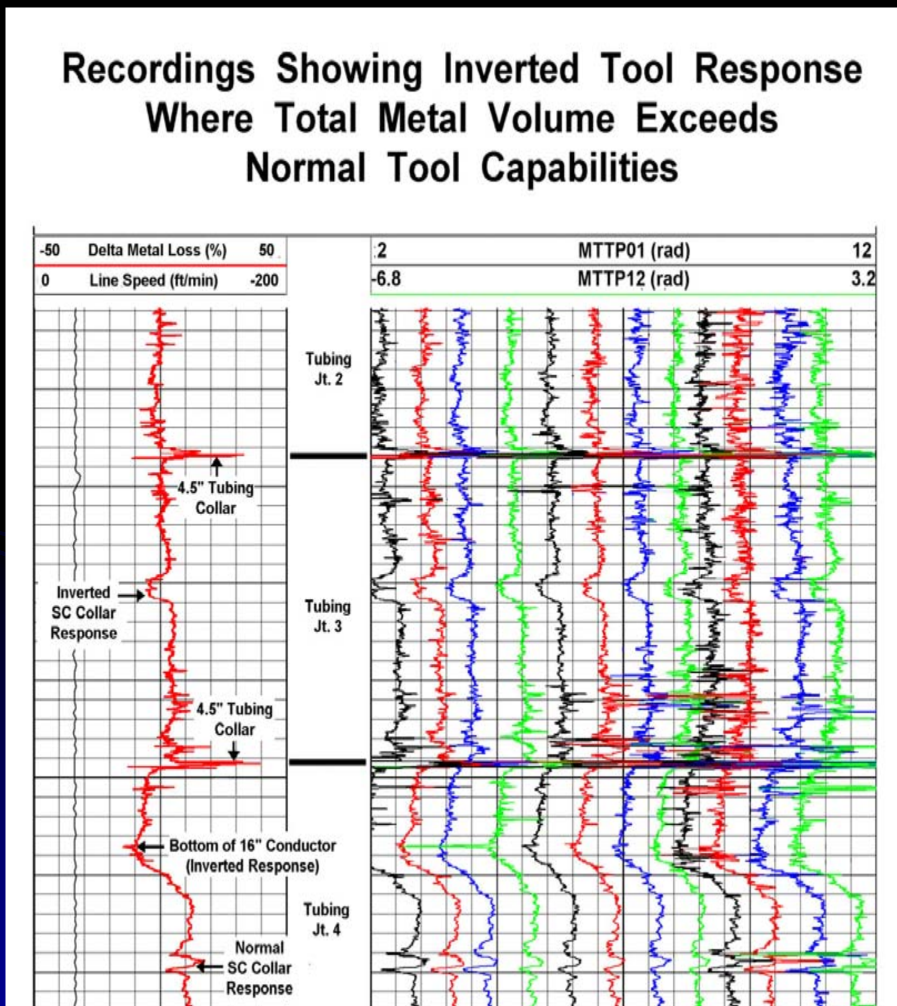


Possible Well Condition



Actual Confirmed Well Condition

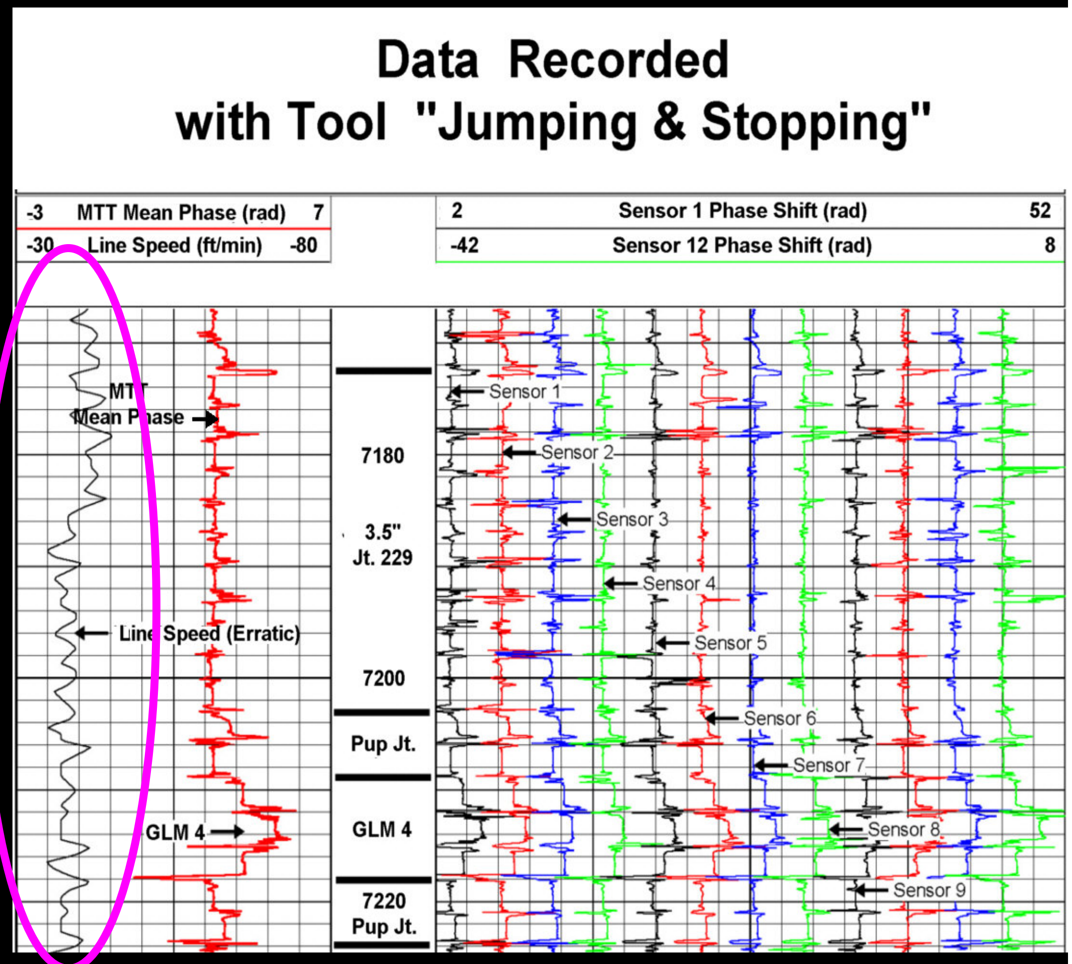
Tool Limitations



- Tool overwhelmed in intervals with
  - 4 concentric casing strings
  - Some 3 concentric casing with large casing sizes.
- Inverted Tool response
  - Noted in some wells w/ 3 concentric rings w

Operational Issues

- Erratic tool speed makes data impossible to interpret
- Irregular tool speed should be evident real time on the wireline weight indicator and is subsequently more closely monitored



Summary

- Good qualitative approach to identify external corrosion and metal loss on middle and outer concentric casing strings.
- Tool works best in smaller casing configurations
- Highest correlation confidence in 16”x5.5”x3.5” tubulars
- Steady logging speed is required
- Used to estimate excavation depth and prioritize proactive inspections