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Getting More From Your Intelligent Pig Inspection

by

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Penspen Integrity

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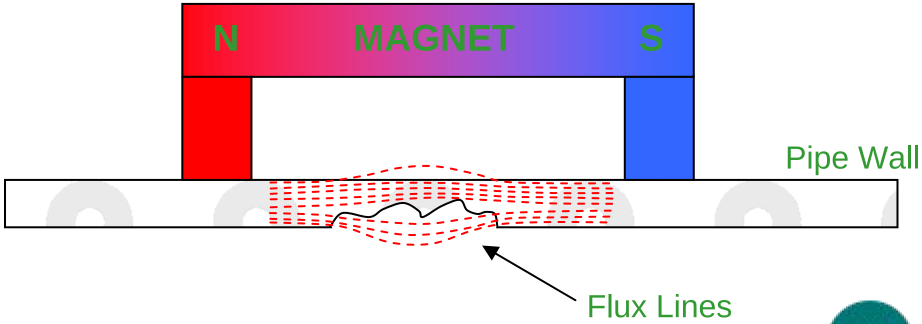
The Problem

- Intelligent pigs are widely used
- Large quantities of data are collected
- Defects are generally reported in a simple spreadsheet format.
- Simple clustering and defect sizing leads to safe conservative assessments

Outline

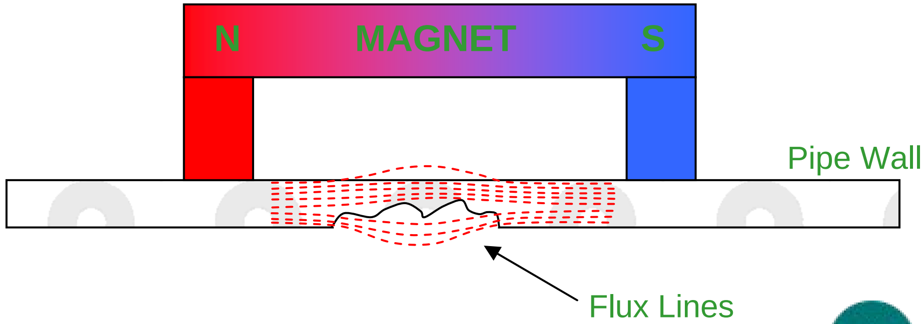
- Inspection Technology
  - MFL
  - UT
- Defect Sizing
- Defect Assessment
- ‘Complex Shape’ Assessment
- Case Study

MFL Inspection

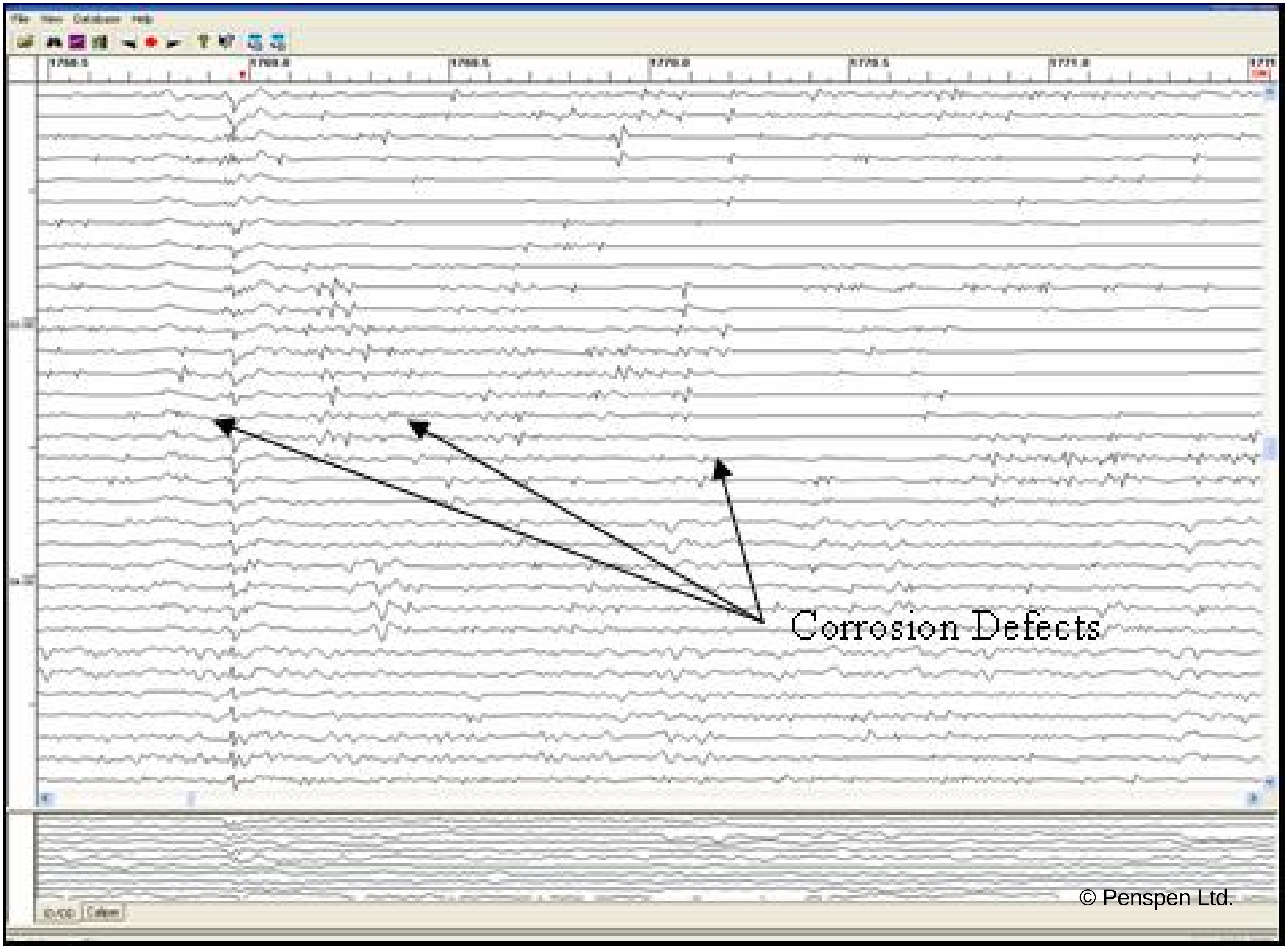


MFL Defect Sizing

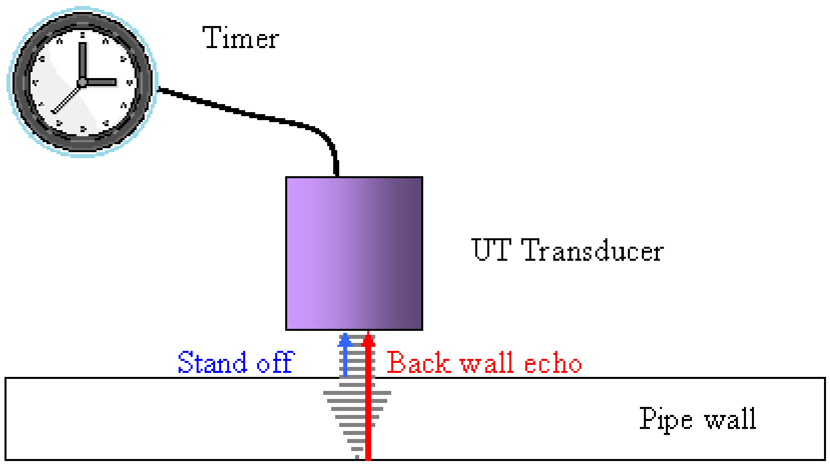
- Relative measurement
- Depth
  - Signal amplitude
  - Number of sensors affected

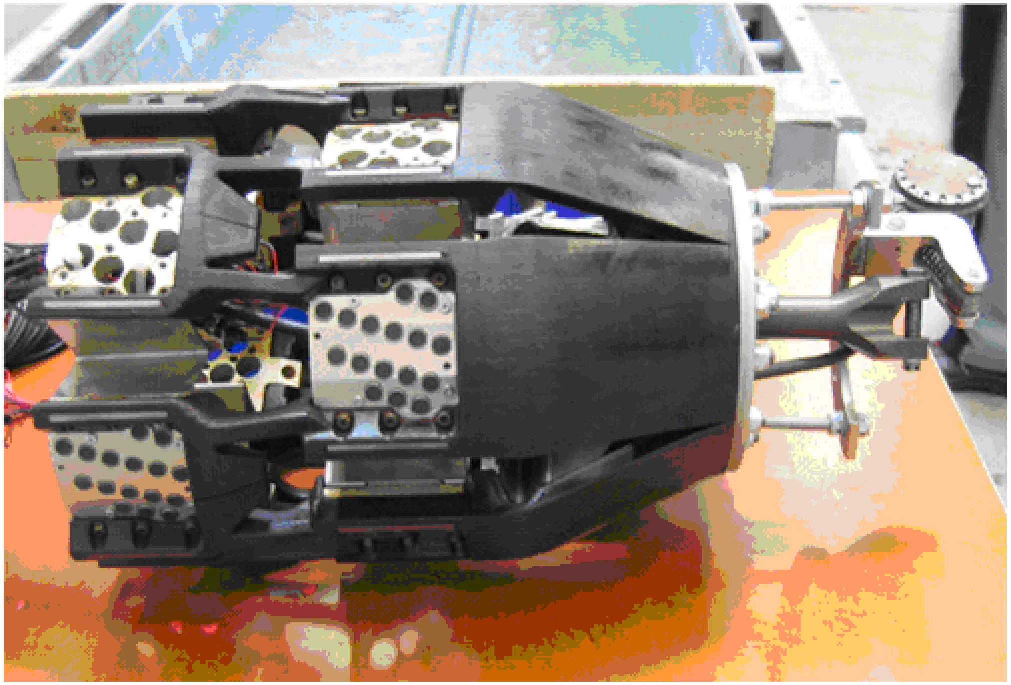


MFL Data



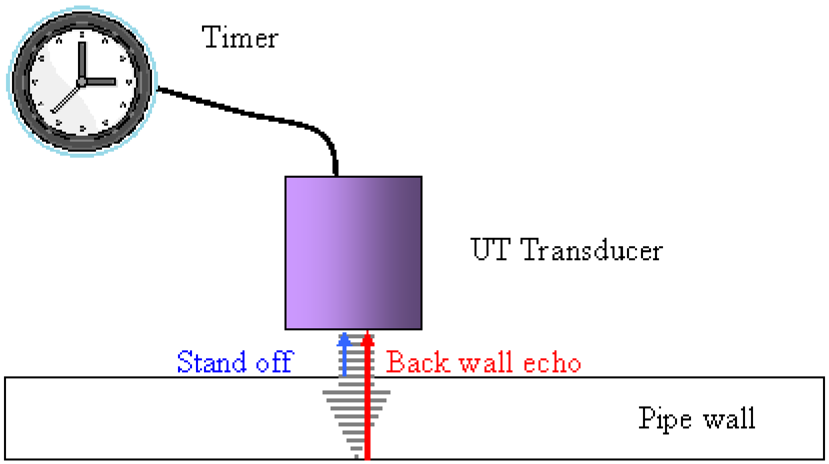
UT Inspection



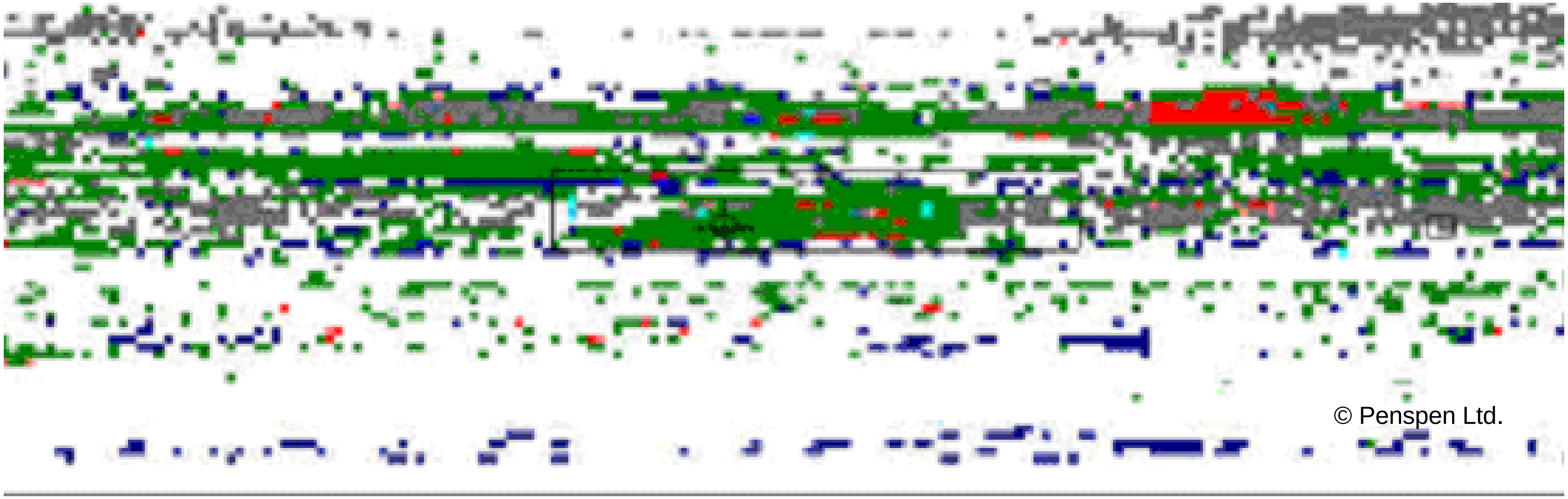


UT Defect Sizing

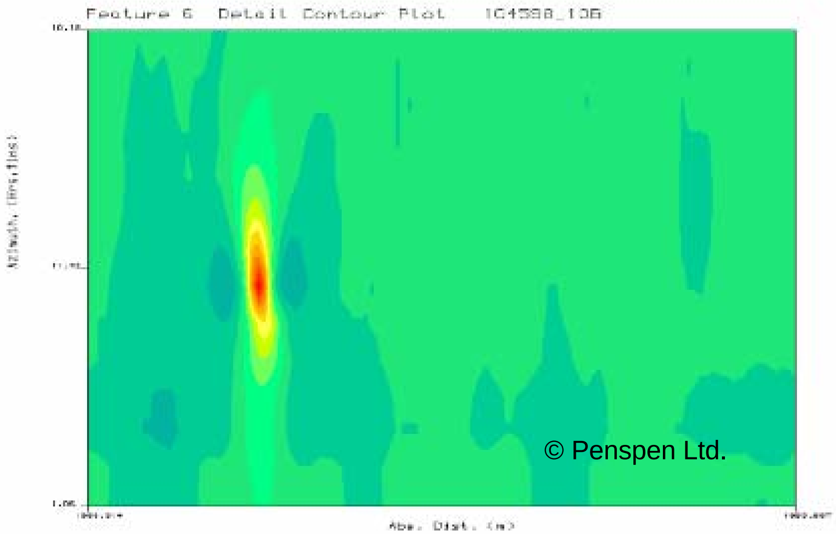
- Absolute Depth/Wall Thickness
  - Time difference between echo signals



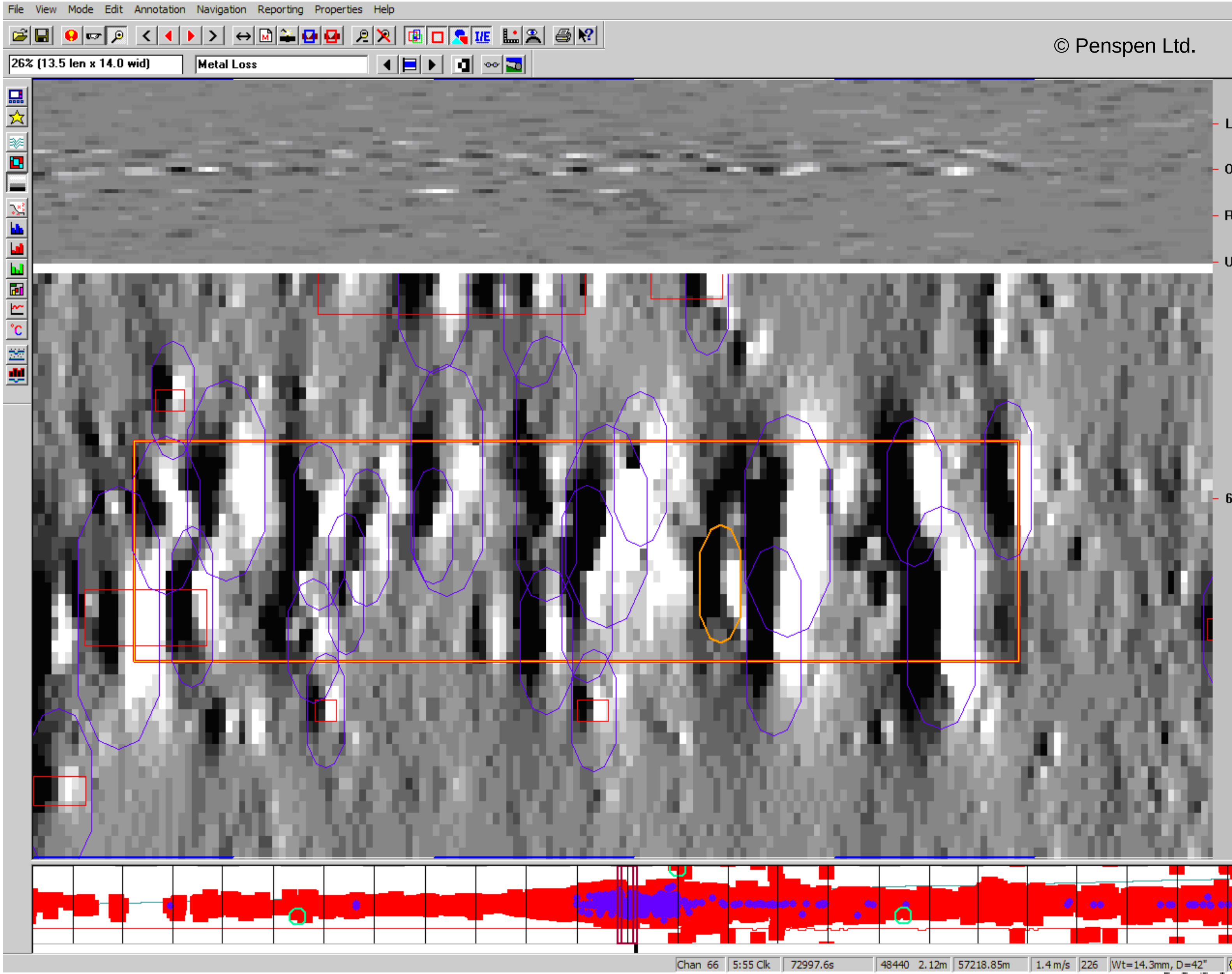
UT Data



Individual Defects



Multiple Defects?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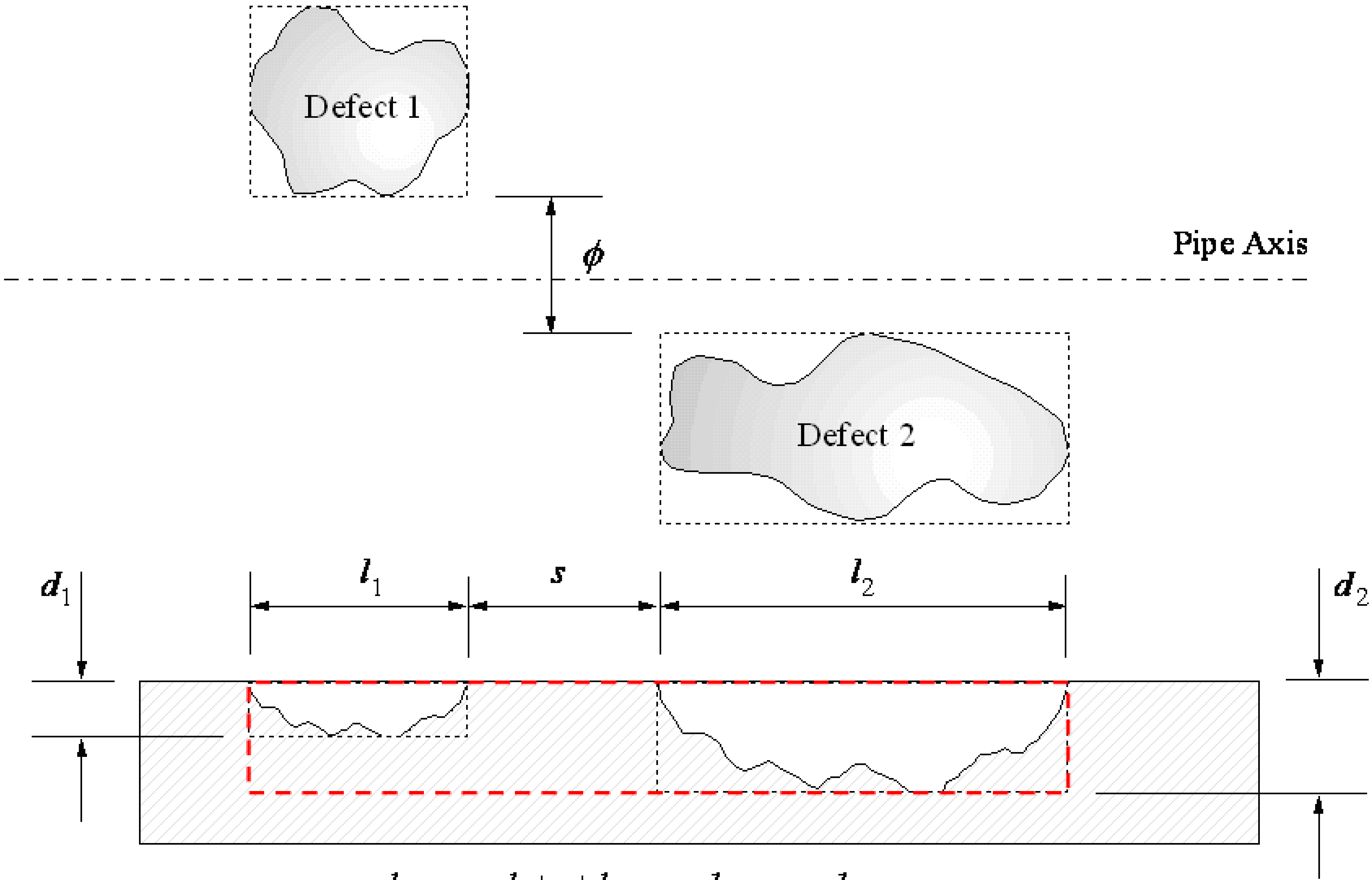
© Penspen Ltd.
26% (13.5 len x 14.0 wid)
Metal Loss
L
O
R
U
6
Chan 66
5:55 Clk
72997.6s
48440 2.12m
57218.85m
1.4 m/s
226
Wt=14.3mm, D=42"

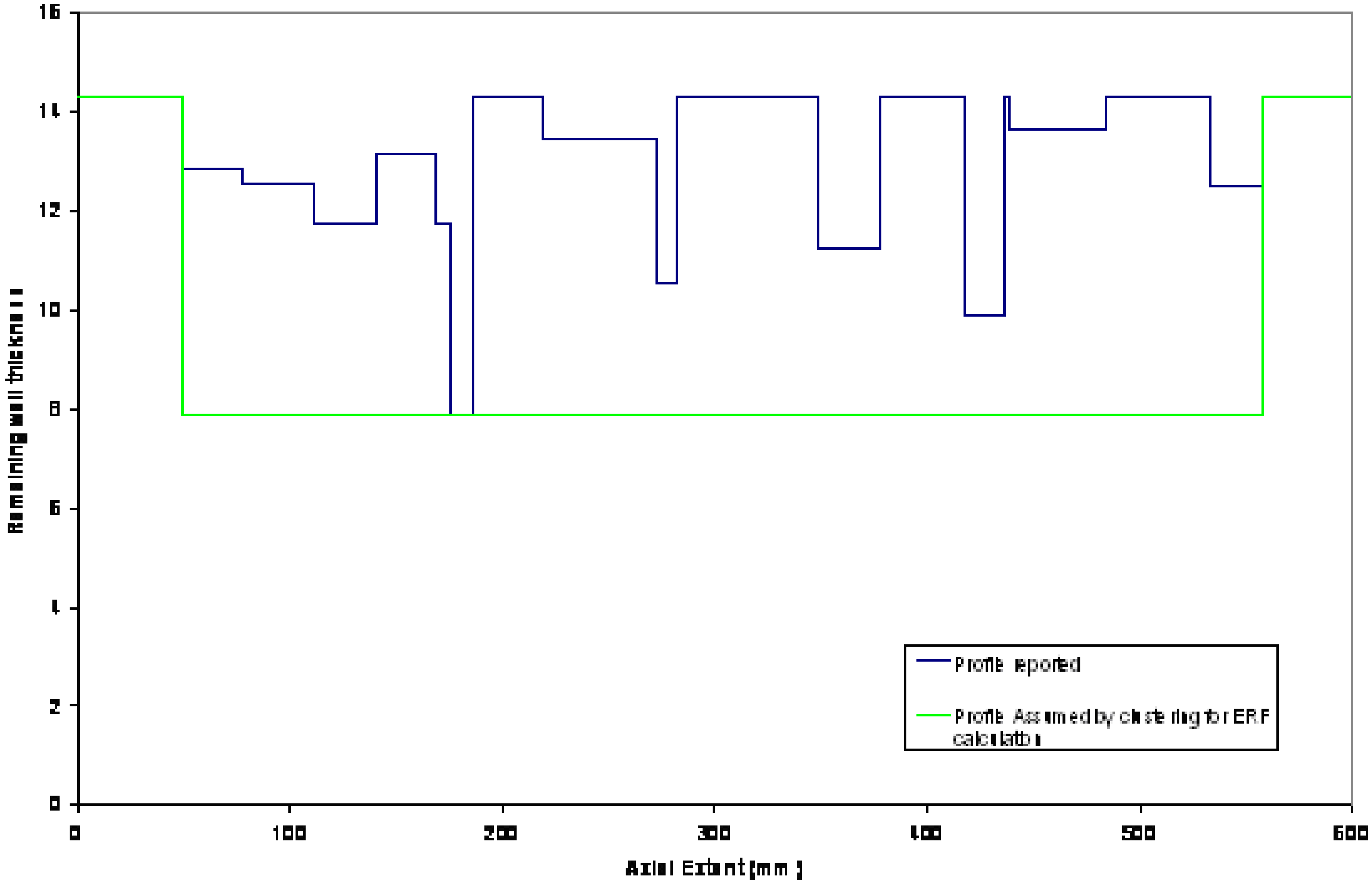
Clustering



$$l_{group} = l_1 + s + l_2 \qquad d_{group} = d_2$$

Upstream Girth Weld	Relative Distance (metres)	Absolute Distance (metres)	Comment	Peak Depth (%wt)	Length (mm)	ERF	Orientatior (hrs:mins)
30	10.6	19.6					
40	9.7	29.4					
50	0.7	30.1	NWT 7.80/9.53MM				
60	3.0	33.1	NWT 9.53/7.80MM				
	0.2	33.3	*EXT ML	21%	79	0.260	02:15
63	0.2	33.3					
68	5.3	38.7					
	0.0	38.7	*EXT ML	40%	694	0.406	05:45
70	0.7	39.4	NWT 7.80/9.53MM				
	0.1	39.6	EXT ML	26%	19	0.245	05:00
80	3.0	42.5	NWT 9.53/7.80MM				

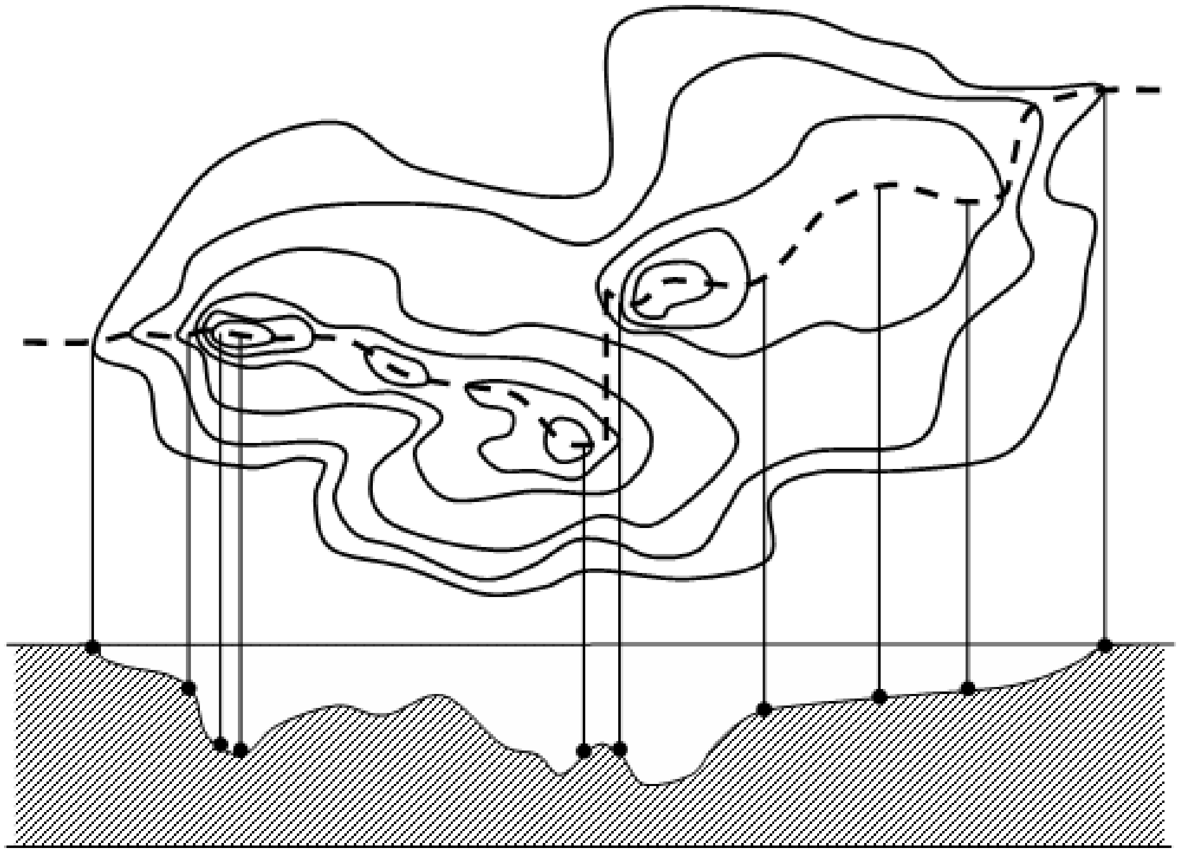
Cluster



16
14
12
10
8
6
4
2
0
0
100
200
300
400
500
600
Remaining wall thickness
Axial Extent (mm)
Profile reported
Profile Assumed by clustering for ERF calculation

Evaluation Based on 'Actual' Shape

- RSTRENG – Riverbottom Profile
- DNV RP-F101 Complex Shape Method



RSTRENG

L	d
mm	mm
0.00	1.27
12.70	1.52
25.40	1.02
38.10	0.25
50.80	1.02
63.50	2.03
76.20	2.54
88.90	2.54
101.60	2.54
114.30	2.54
127.00	2.79
139.70	5.08
152.40	3.81
165.10	2.54
177.80	2.79
190.50	2.79
203.20	2.79
215.90	2.54
228.60	1.02
241.30	0.51
254.00	0.00

20. CORROSION

20.12 INTERNAL PRESSURE (BURST)

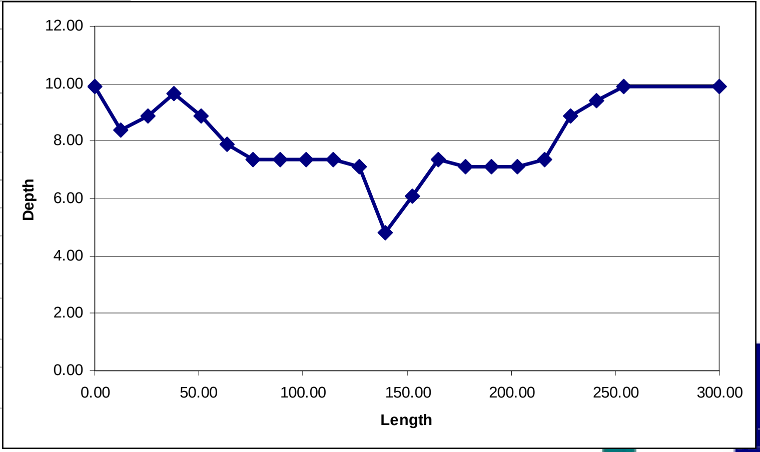
(RSTRENG)

KIEFNER,J.F., VIETH,P.H.; *A Modified Criterion for Evaluating the Strength of Corroded Pipe*, Final Report for Project PR 3-805 to the Pipeline Supervisory Committee of the American Gas Association, Battelle, Ohio, 1989.

Reference should be made to the Pipeline Defect Assessment Manual

RUN ANALYSIS

	symbol, units	value
outside diameter	D, mm	914.4
wall thickness	t, mm	
specified minimum wall thickness	t, mm	9.906
hydrotest pressure	bar	75.0
design pressure	bar	60.0
MAOP	bar	60.0
minimum design temperature	C	
grade (API 5L or equivalent)		X60
SMYS	Nmm^{-2}	413.7
SMTS	Nmm^{-2}	517.1
maximum corrosion defect depth	d, mm	5.08
	d/t, percent	51.28
maximum corrosion defect length (longitudinal)	2c (L), mm	254.0
predicted failure stress	**Nmm^{-2}**	**413.63**
predicted failure pressure	**P_f, bar**	**89.62**
safe operating pressure	**P_{sop}, bar**	**59.99**



DNV RP-F101

PIPELINE DEFECT ASSESSMENT MANUAL			
20. CORROSION			
20.12 INTERNAL PRESSURE (BURST)			
DNV-RP-F101, *Corroded Pipelines*, Det Norske Veritas, 1999.			
Reference should be made to the Pipeline Defect Assessment Manual			
	symbol, units	value	RUN ANALYSIS
outside diameter	D, mm	762.0	
wall thickness	t, mm		
specified minimum wall thickness	t, mm	22.1	
hydrotest pressure	bar	75.0	
design pressure	bar	60.0	
MAOP	bar	60.0	
grade (API 5L or equivalent)		X60	
SMYS	Nmm^{-2}	413.7	
SMTS	Nmm^{-2}	517.1	
2/3 Charpy V-notch impact energy	J	62.0	
maximum corrosion defect depth	d, mm	17.1	
	d/t, percent	77.38	
maximum corrosion defect length (longitudinal)	2c (L), mm	572.0	
'lower bound' predicted failure stress	**Nmm^{-2}**	**201.81**	
'lower bound' predicted failure pressure	**P_f, bar**	**120.56**	
safe operating pressure	**P_{sop}, bar**	**86.8**	

L	d
mm	mm
0.00	0.00
0.00	3.90
0.80	7.39
1.60	8.70
2.40	9.61
3.20	10.30
4.00	10.83
4.80	11.23
5.60	11.53
6.40	11.74
7.20	11.86
8.00	11.90
163.00	11.90
169.20	12.42
175.40	13.41
181.50	14.28
187.70	15.04
193.90	15.67
200.00	16.19
206.20	16.59
212.30	16.87
218.40	17.04
224.50	17.10
230.60	17.04
236.70	16.87
242.80	16.59
249.00	16.19
255.10	15.67
261.30	15.04
267.50	14.28
273.60	13.41
279.80	12.42
286.00	11.30
292.20	12.42
298.40	13.41
304.50	14.28
310.70	15.04
316.90	15.67
323.00	16.19
329.20	16.59
335.30	16.87
341.40	17.04
347.50	17.10
353.60	17.04
359.70	16.87
365.80	16.59
372.00	16.19
378.10	15.67
384.30	15.04
390.50	14.28
396.60	13.41
402.80	12.42
409.00	11.90
564.00	11.90
564.80	11.86
565.60	11.74
566.40	11.53
567.20	11.23
568.00	10.83
568.80	10.30
569.60	9.61
570.40	8.70
571.20	7.39
572.00	3.90
572.00	0.00

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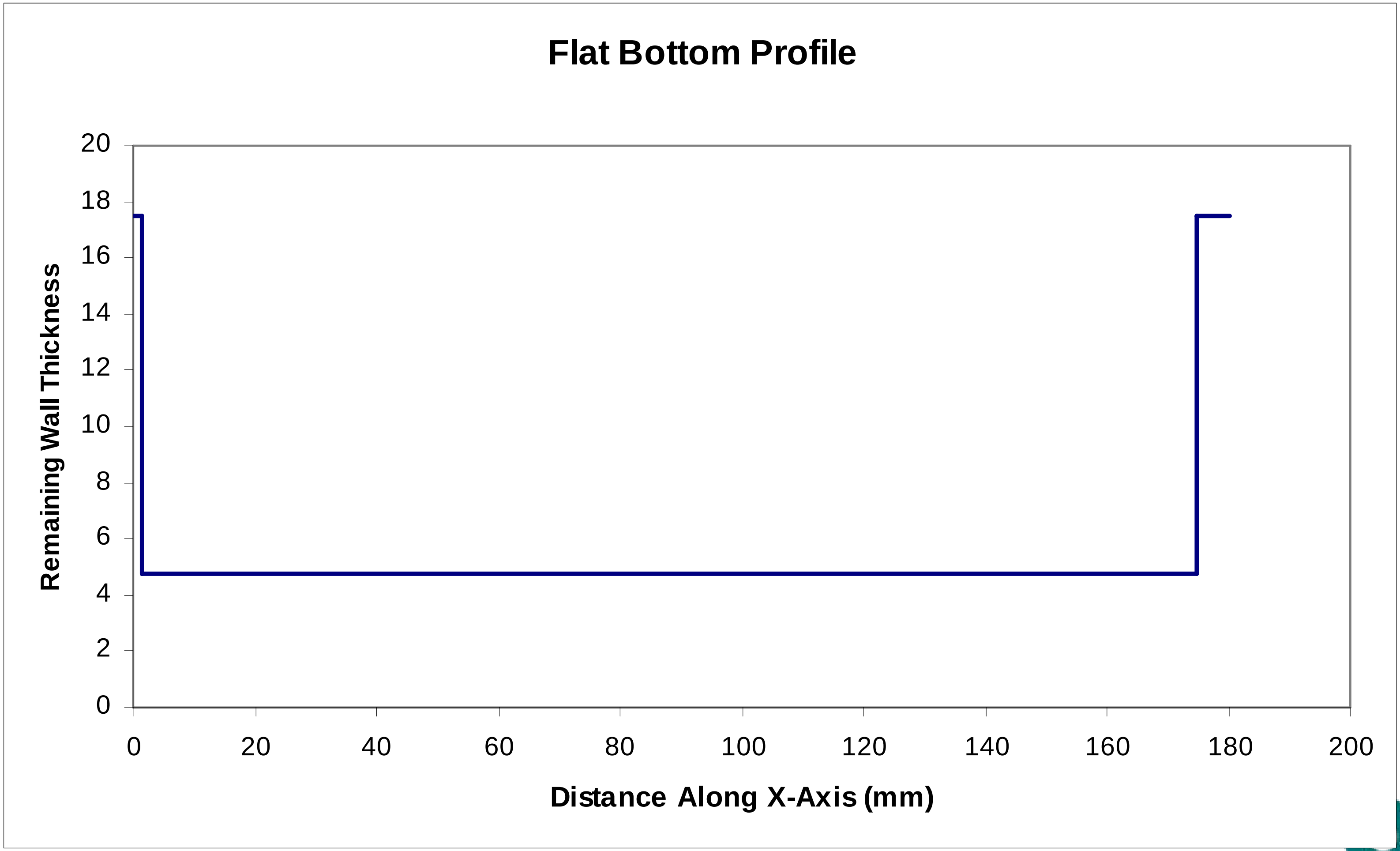
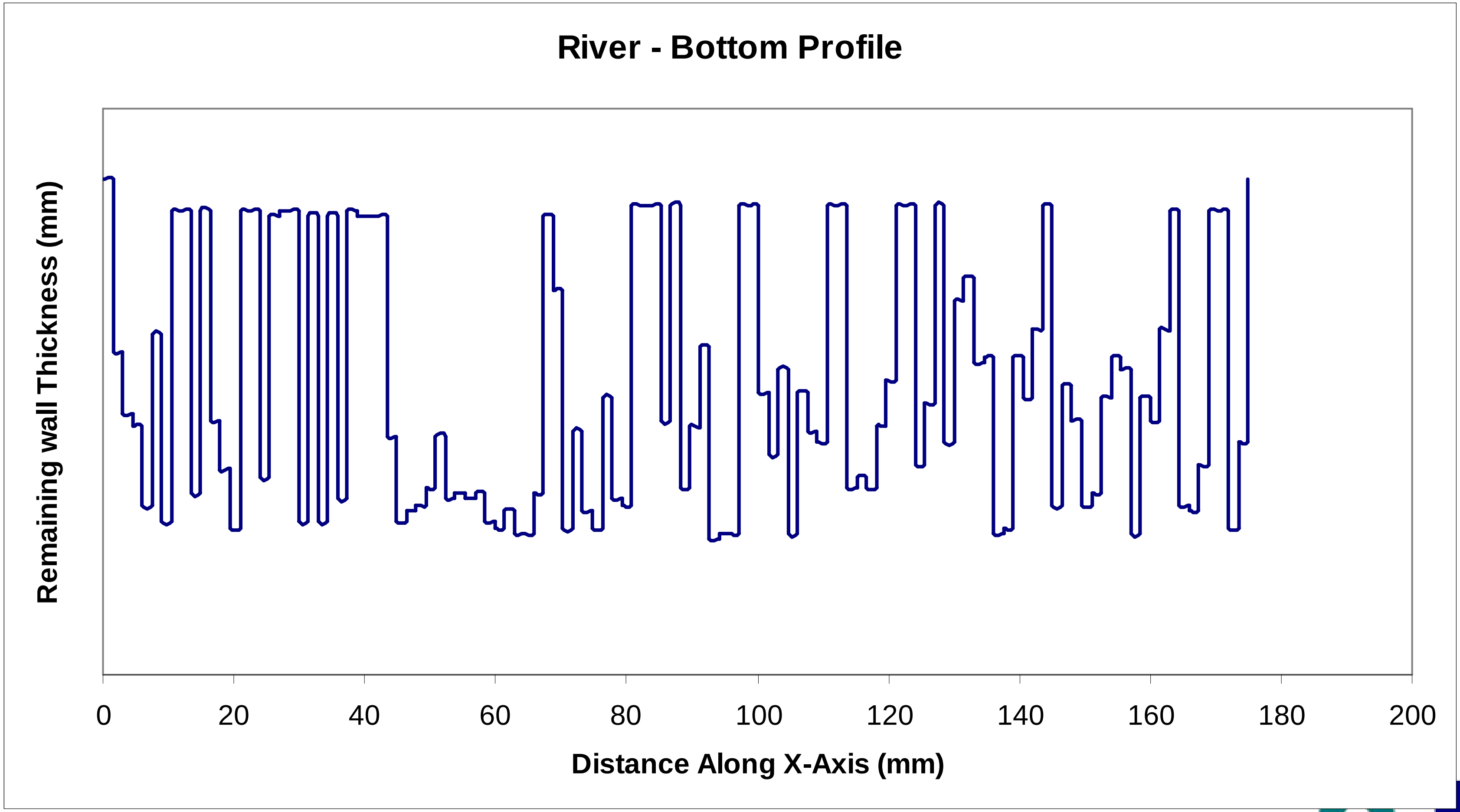
Example 1

UT data

Rectangular Profile
Failure Pressure 219 bar



Riverbottom Profile
Failure Pressure 305 bar



Example 2

Assessment	Data	Maximum Reported Depth (%t)	Length (mm)	Defect Profile	Failure Pressure (Bar)
Standard	MFL pig 'Cluster'	63	330	Rectangular	53
Expert	MFL pig ' Boxes'	63	330	'River-Bottom'	113
Expert	External UT	50.5	1760	'River-Bottom'	85

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Inspection/Repair Can be Expensive

Summary

- Defect profile data gives assessment benefits
- Profile data is collected anyway and so should be supplied in an accessible format with the inspection report.