Hydrostatic Testing of In-Situ Pipelines & Spike Testing

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6/27/18

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Hydrotest Design and Support: Statistics

Piping and Test Heads

Overall: GTS has designed hydrotests for over **1,000** miles of in-situ pipelines on over **500** projects. Pipeline diameters ranging from 2” to 42” on lines dating back to the 1920’s.

Agenda

- Hydrostatic Testing Overview
  - Why Hydrotest – NPRM Synthesis/Update
  - Essential Elements of a Hydrotest
  - In-Situ Testing Considerations

- Spike Testing
  - Why Include a Spike Test into your Hydrotest - NRPM
  - Flaw Growth Over Time
  - When is Spike Testing Appropriate
  - Test Pressure Determination

- Lessons Learned
  - Considerations for Value Add and Cost Savings

Why Hydrostatic Test –NPRM Synthesis

Revision to the code proposes to effectively eliminate the "grandfather" clause - used to establish MAOP on non-tested pre-1970 lines.

- Per GPAC March Meeting ~6,800 miles meet this criteria

Timeline to establish MAOP

- 15 Years from Effective Date of the Ruling

Methods for Determining and Establishing MAOP

1. **Hydrostatic Test**
2. Pressure Reduction commensurate with a test factor
3. Perform an Engineering Critical Assessment (fracture mechanics and material properties)
4. Pipe Replacement
5. Pressure Reduction for Lines <30% SMYS
6. Alternative Technology

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Essential Elements - Hydrotest Overview

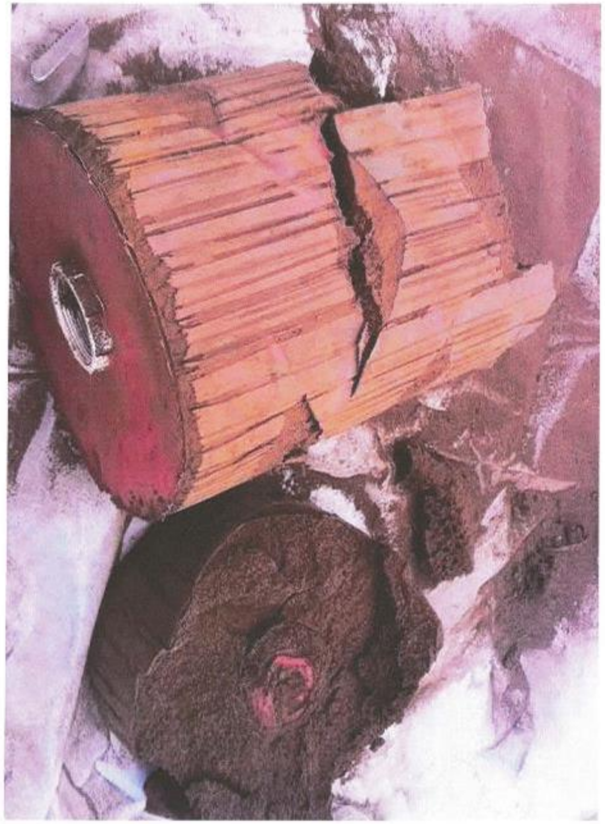
In-Situ Testing Considerations

Important to remember: Many other factors to account for when testing an in-situ line compared to a new line

Preliminary Engineering

- Validate physical properties of features
- Uncover unknown features (taps, PCFs, etc.)
- Other impediments to pigging
- Optimize test section

In-Situ Testing Considerations



In-Situ Testing Considerations

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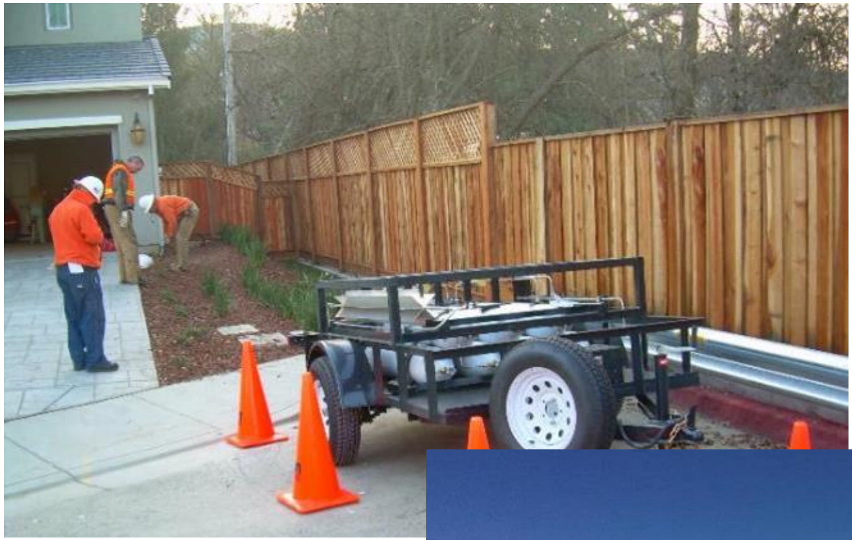
Outage Management

- Up to 2 Week outage compared to 1- 2 day outage
  - Services on the line being tested?
  - Radial feed line?

In-Situ Testing Considerations



In-Situ Testing Considerations

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Cleaning

- Possibilities of residual contaminants in operational lines
  - Protrusions and debris can hinder cleaning/clearing
  - You don't always know what may be in your line!

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Water Handling

- Possible contaminants, liquids, etc. compared to a clean brand new line
  - Filters
  - Water Sampling
  - BMPs and a response plan in the event of a rupture

In-Situ Testing Considerations

Spike Testing

Why Spike Test?

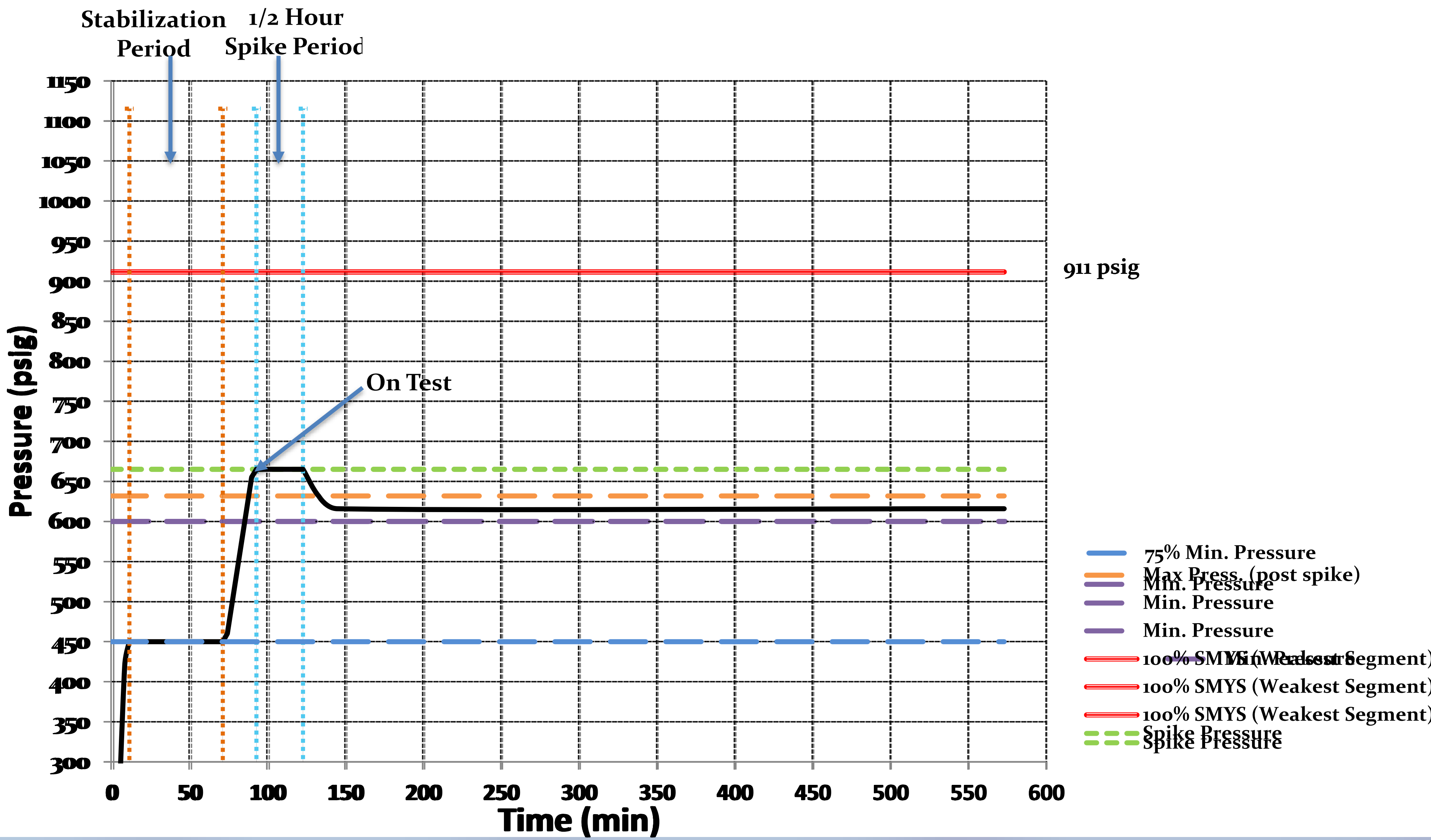
1. Current GPAC stance is no Spike Test is required as part of a Hydrotest being used to establish MAOP

2. Rules out critical flaws including SCC and long seam defects.

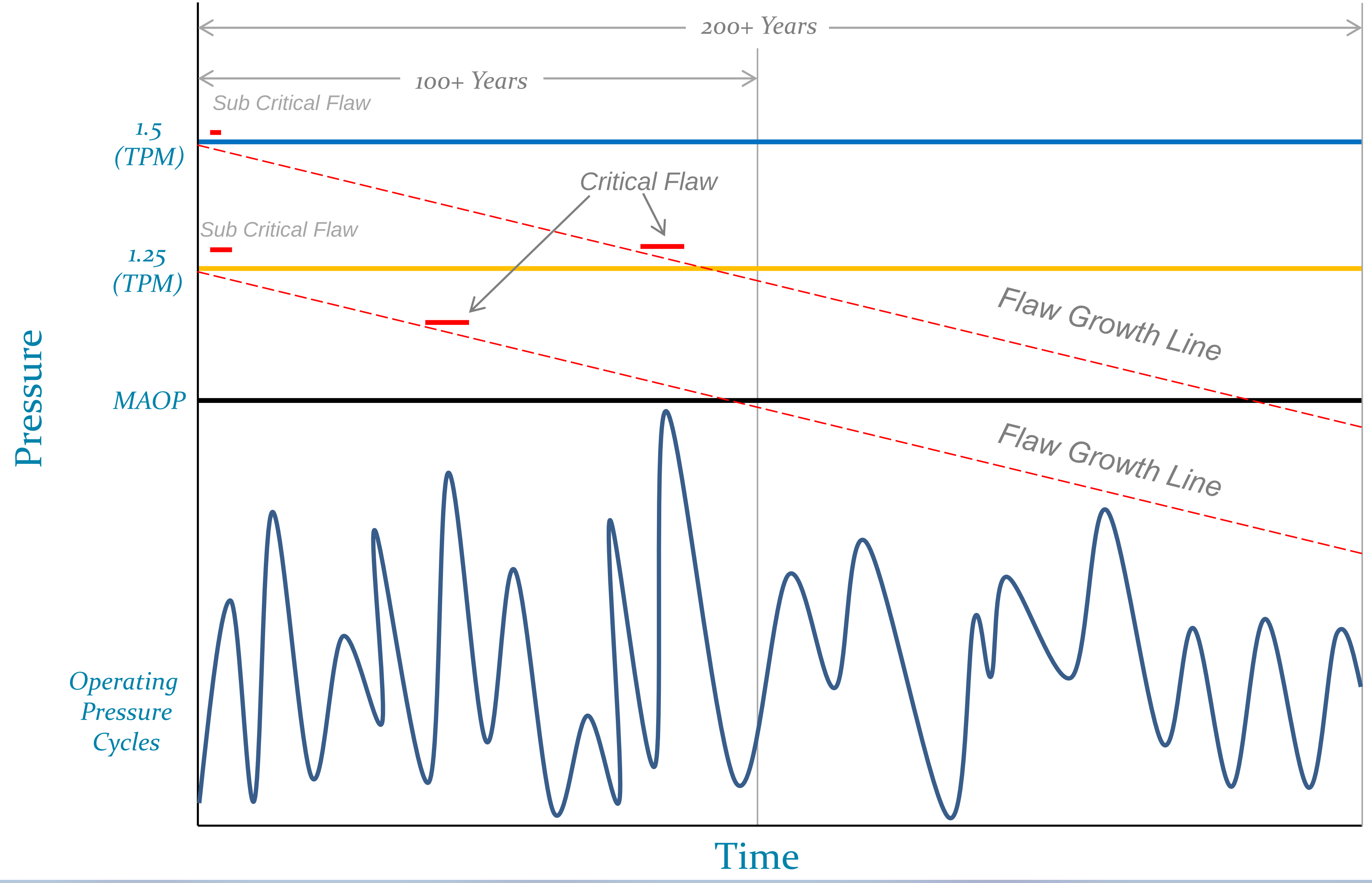
3. Minimizing size of “just-surviving” flaws

4. Subsequent to Spike Hold period, relaxing the test pressure by 10% (minimum of 5% if 10% cannot be achieved due to test parameters) as research shows the reduction will generally stop or stabilizes crack growth and avoids continued subcritical crack growth

Sample Spike Test PvT Graph



Flaw Growth Over Time



When is Spike Testing Appropriate?

Various Kiefner & Associates reports on hydrostatic testing identify variations of three (3) categories for the suitability of a spike test:

Spike testing is beneficial to:

- Rule out time dependent and manufacturing threats and can extend not only re-assessment interval but life of pipe

Spike testing is less necessary on:

- Newer pipe, and lines operating at lower SMYS (<40%)

Spike Testing can be inadvisable when:

- Exceeding mill test pressures or to extremes that would cause plastic deformation
- Test pressures do not allow for significant enough reduction in pressure so as to restrain sub critical flaw growth

Test Pressure Determination

Ratings of Fitting and Max Shell Test Pressure

Test Pressure Determination

Ratings of Fitting and Max Shell Test Pressure

Elevation Changes Causing Static Head

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Test Pressure Determination

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Review Leak and CP History on the Line

Test Pressure Determination

- Ratings of Fitting and Max Shell Test Pressure
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- Mill Test Pressures and Documentation

Test Pressure Determination

Ratings of Fitting and Max Shell Test Pressure

Elevation Changes Causing Static Head

Review Leak and CP History on the Line

Mill Test Pressures and Documentation

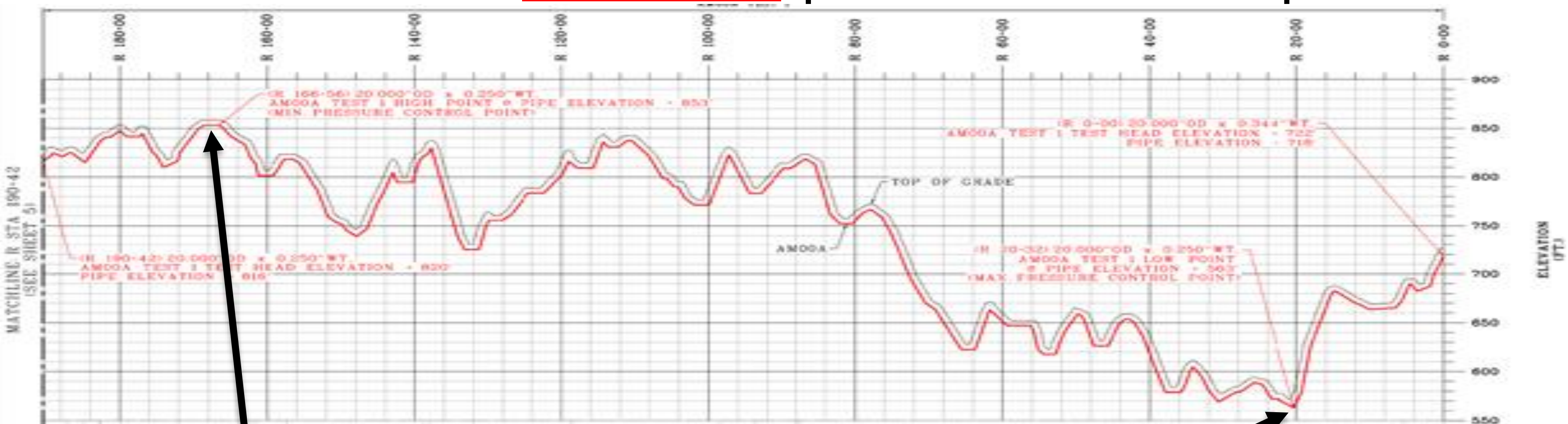
Extend IM Reinspection Interval

Table 3 Integrity Assessment Intervals: Time-Dependent Threats, Prescriptive Integrity Management Plan

Inspection Technique	Interval (Years) [Note (1)]	Criteria: At or Above 50% SMYS	Criteria: At or Above 30% up to 50% SMYS
Hydrostatic testing	5	TP to 1.25 times MAOP [Note (2)]	TP to 1.4 times MAOP [Note (2)]
	10	TP to 1.39 times MAOP [Note (2)]	TP to 1.7 times MAOP [Note (2)]
	15	Not allowed	TP to 2.0 times MAOP [Note (2)]
	20	Not allowed	Not allowed

Test Pressure Considerations

Ensure Proper Planning and Communication of Maximum and Minimum pressure control point



Min Pressure Control Point

Max Pressure Control Point

LOCATION	R STA.	ELEV.	SPIKE PRESSURE	MIN. PRESS	MAX. PRESS
MIN. PRESSURE CONTROL POINT	166+56	853'	690 PSIG	588 PSIG	
MAX. PRESSURE CONTROL POINT	20+32	563'	816 PSIG		734 PSIG
LOCATION 1 (VERIFICATION STATION)	0+00	722'	747 PSIG	645 PSIG	665 PSIG
LOCATION 2 (TEST STATION)	190+42	820'	705 PSIG	603 PSIG	622 PSIG

Considerations and Lessons Learned

Methods and considerations for a cost effective hydrotest or hydrotest program:

Planning Lessons **Engineering Lessons** **Execution Lessons**

Planning Lessons Learned

Geographical Grouping

- Careful consideration of your program should be made to cluster project sites:
  - Environmental and Ministerial Permits
  - Public Convenience
  - Efficient Outage Management
  - Reduce Mobilization and improves access

Test Splitting

- Review elevations particularly in long stretches of untested line
- Can “leap frog” or “daisy Chain” tests utilizing water from tests on adjacent portions of the line

Planning Lessons Learned

Engineering Lessons Learned

Proper pipeline asset knowledge is critical to the successful design of a hydrotest

- Comprehensive Pipeline Features List (PFL)
  - Identifies all unpiggable features
  - Provides pipeline specifications to determine test pressures
  - Identifies underrated features

Engineering Lessons Learned

Feature Number	Start Station	End Station	Line ID	Class Location	Install Date	Feature	Type	Feature by Feature Length (ft.)	Current MAOP (psig)	Normal Operating Pressure (psig)	O.D. 1	W.T. 1
570	0+08.5	0+09.2	B002	3	5/24/2011	Tee	Straight Tee	0.7	500	500	4.5	Unknown
571	0+09.2	0+11.5	B002	3	5/24/2011	Pipe	No Casing	2.3	500	500	4.5	Unknown
574	194+32.5	194+95.5	L001	3	5/24/2011	Pipe	No Casing	63.0	500	500	12.75	0.250
575	194+95.5	194+98.0	L001	3	5/24/2011	Valve	Plug	2.5	500	500	12.75	0.250
576	194+98.0	195+03.0	L001	3	5/24/2011	Pipe	No Casing	5.0	500	500	12.75	0.250
577	195+03.0	195+06.0	L001	3	5/24/2011	Elbow	Unknown	3.0	500	500	12.75	0.250

Engineering Lessons Learned

Proper pipeline asset knowledge is <u>critical</u> to the successful design of a hydrotest

- Comprehensive Pipeline Features List (PFL)
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Future Planning

- Prep line to accommodate smart pigs?
- Test for Other factors (IM)
  - Casing with an IM assessment requirement
  - Pipeline requires future DA? Increase test factor from 1.5 to 1.7 to extend assessment to 7 years

Contingency Material

Engineering Lessons Learned

Execution Lessons Learned

Test Monitoring

- Test certification tool to monitor real time pressure fluctuations
  - Will provide information on if pressure drop is on account of a leak or temperature change

Leak Contingency Planning

- Prepare and identify most likely locations for leaks
  - Seam Type, pipe vintage, low points
- Have an isolation plan
- Have BMP Equipment on standby during test

Questions?

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Additional Information

GTS will be providing Part II of a webinar series with additional hydrotest information on **TBD**

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Appendix

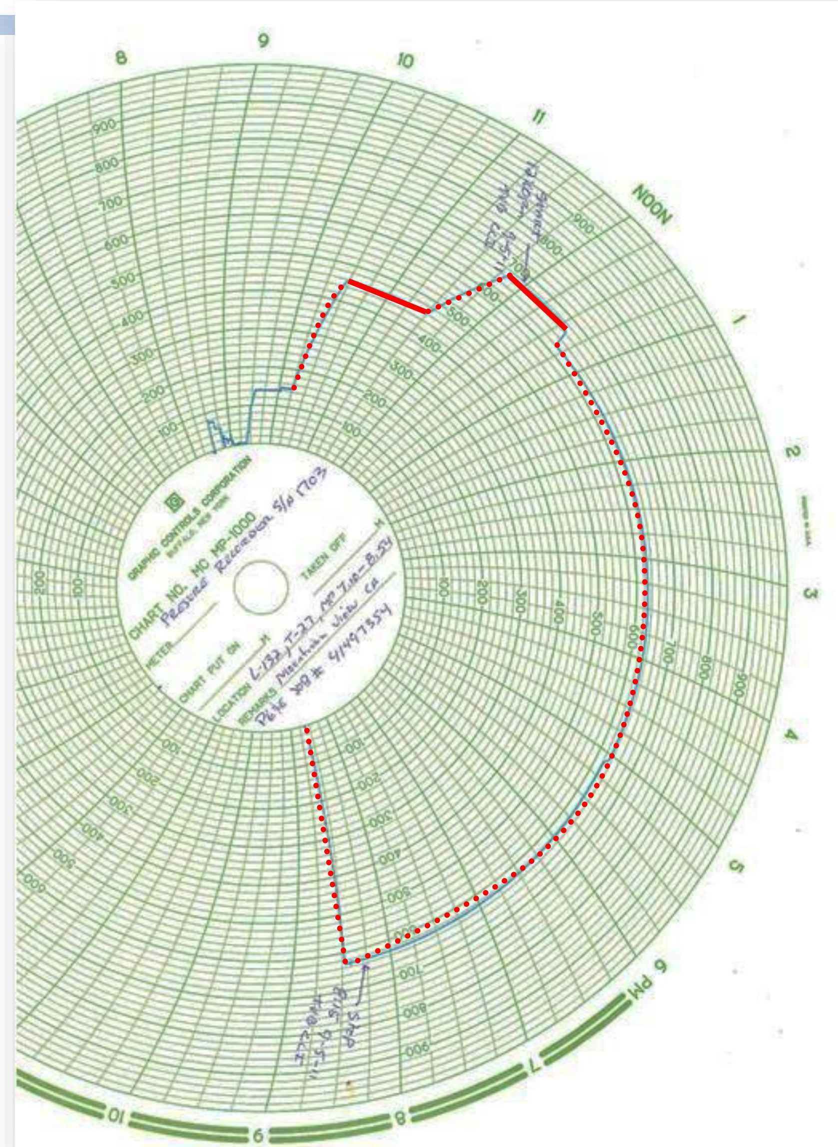
Hydrotest Design and Support

Water Management and Test Equipment



Test Steps

- Temperature Stabilization
- Pre-Test Leak Identification
  - Monitor Fill pump pressure
  - 1 Hr P Stabilization @ 75% Min TP
- Spike Test for 30 min (max) Hold Period - 7.5 Hrs
- De-pressure and Dewater

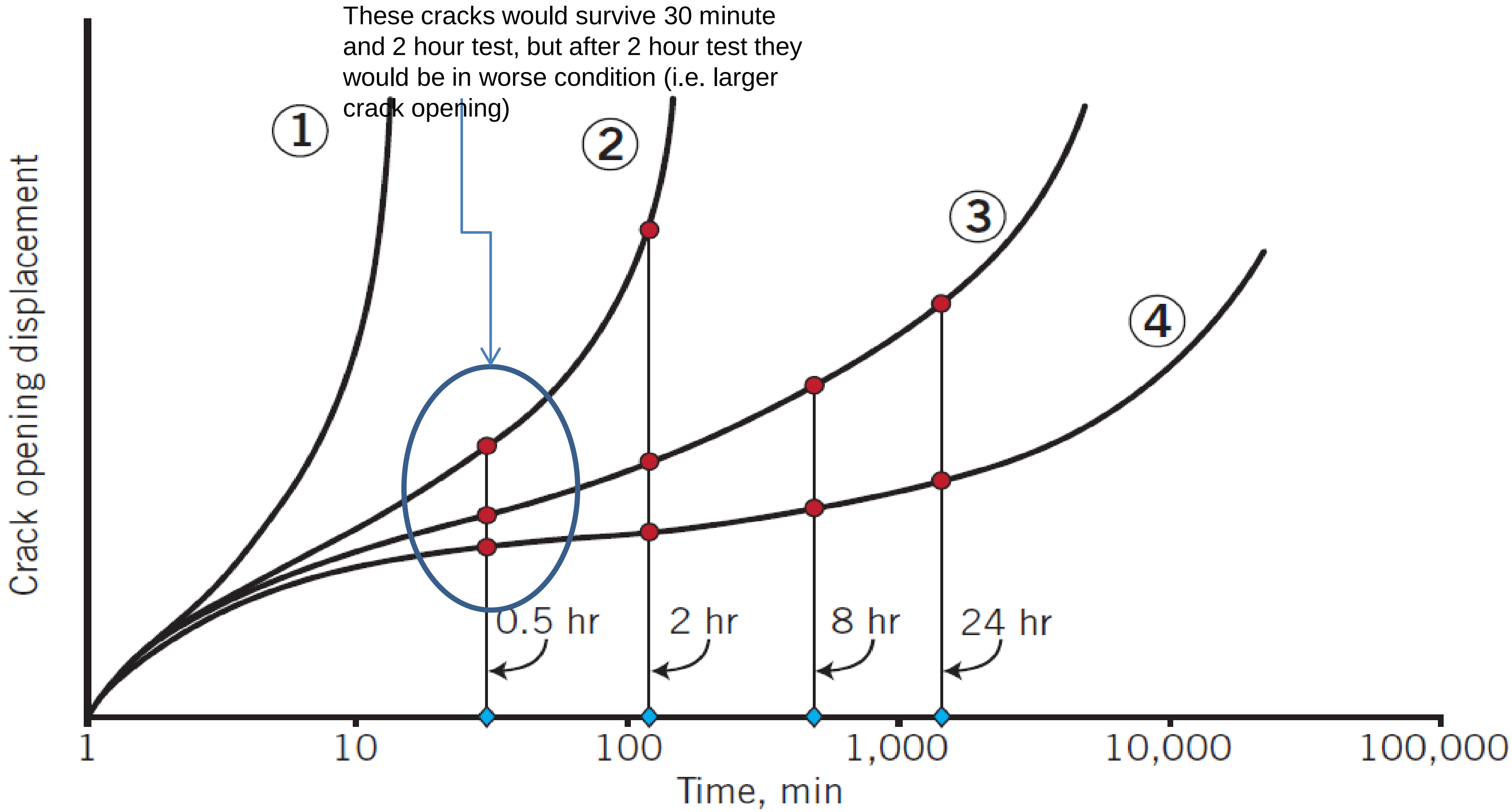


Test Duration Determination

Longer test duration does not necessarily mean safer pipeline upon completion!

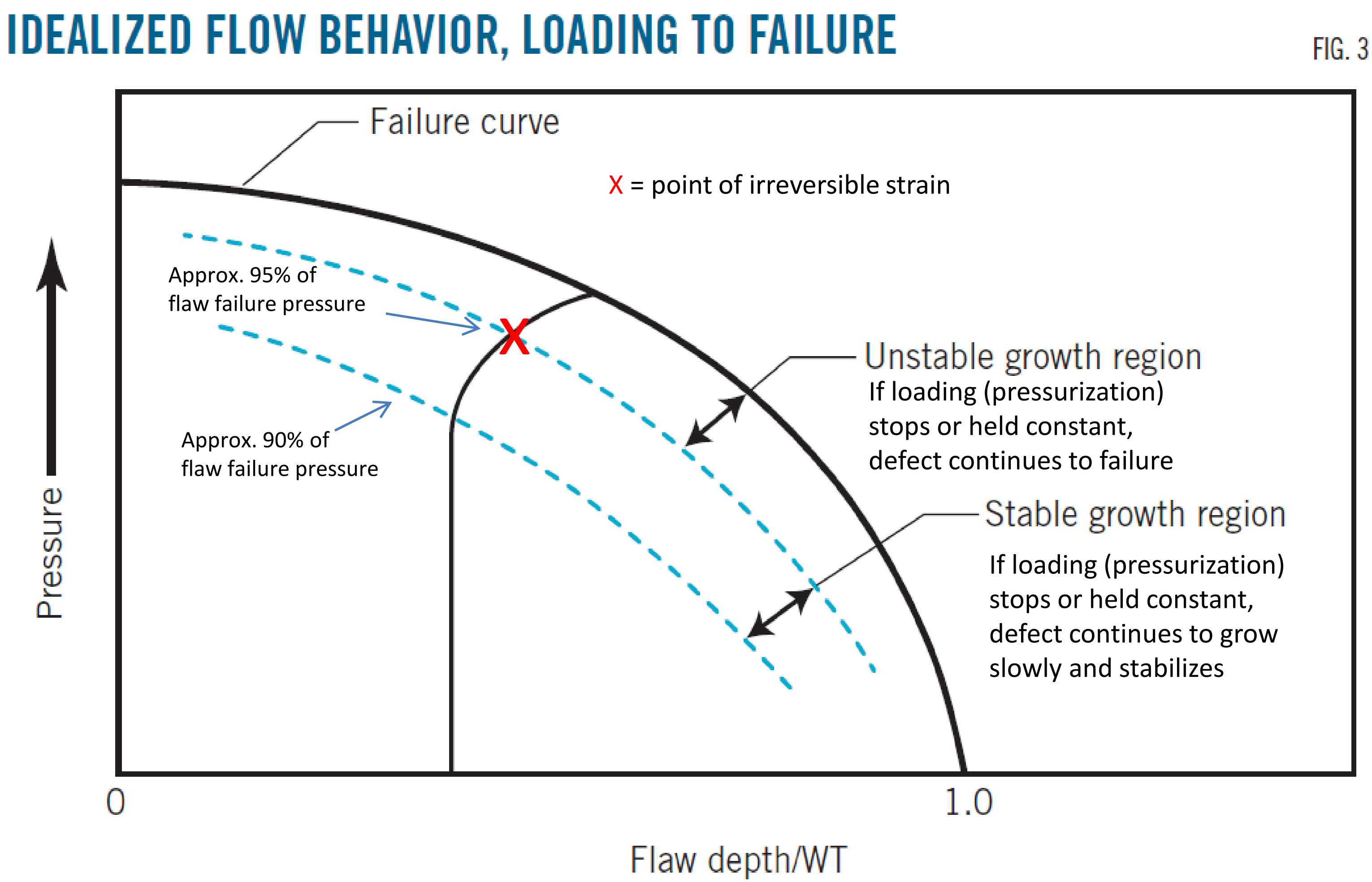
DEFECTS UNDERGOING UNSTABLE CRACK GROWTH, HYDROTEST

FIG. 5



Reprinted with Comments added - Harvey Haines, John Kiefner & Mike Rosenfeld, “Study questions specified hydrotest hold time’s value”, Oil & Gas Journal, March 5, 2012.

Flow Behavior, Loading To Failure



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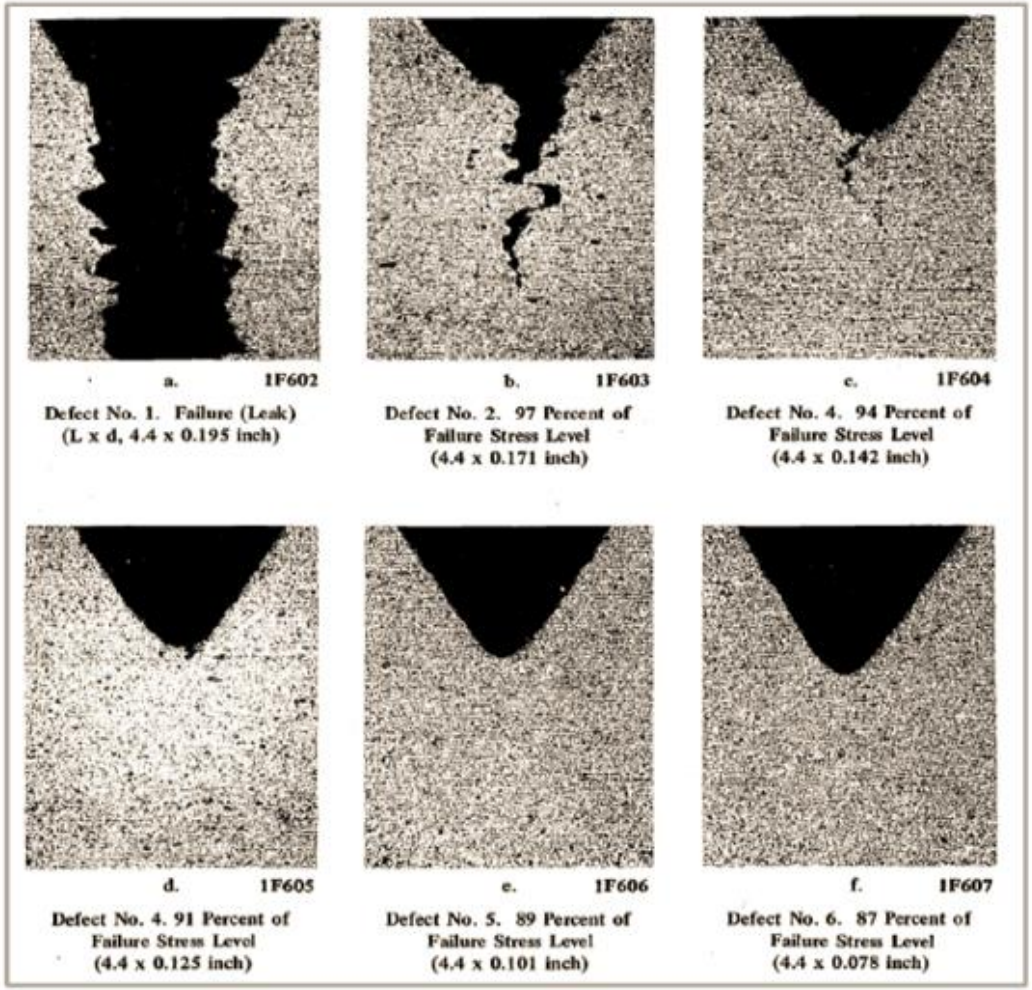
Defects Held at a Stress Near Failure

Note: Loading Consisted of:
1st cycle – 0 to 1330 psig, 30 sec hold
2nd cycle – 0 to 1330 psig, 30 sec hold
3rd cycle – 0 to 1230 psig, failure



Flaw growth from pressure cycling near the failure stress level, from PRC/AGA NG-18 Report No. 111,
Kiefner, J.F., Maxey, W.A., and Eiber, R.J., “A study of the Causes of Failure of Defects That Have Survived a Prior Hydrostatic Test”, 11-3-80

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Diameter	Wall Thickness	Grade, psi	MAOP, psig	Test Pressure, psig	Ratio of Test Pressure to MAOP	Minimum Time to Failure, years
30"	0.375"	52,000	400	790 (60.77%)	1.975	438
30"	0.375"	52,000	400	680 (52.31%)	1.7	221
30"	0.375"	52,000	400	600 (50.00%)	1.5	126
30"	0.375"	52,000	400	500 (level below minimum allowed)	1.25	46.3
30"	0.375"	52,000	400	440 (level below minimum allowed)	1.1	21.4

Effects of Test-Pressure-to-MAOP Ratio on Times to Failure Caused by Pressure-Cycle-Induced Fatigue Crack Growth of an Initial Flaw (for a Class 3 Segment)

Diameter	Wall Thickness	Grade, psi	MAOP, psig	Test Pressure, psig	Ratio of Test Pressure to MAOP	Minimum Time to Failure, years
30”	0.375”	52,000	890	1237 (95.2%)	1.39	216
30”	0.375”	52,000	890	1113 (85.6%)	1.25	110
30”	0.375”	52,000	890	979 (75.3%)	1.1 (not allowed in a test with water)	43

Effects of Test-Pressure-to-MAOP Ratio on Times to Failure Caused by Pressure-Cycle-Induced Fatigue Crack Growth of an Initial Flaw (for a Class 1 Segment)

Lower test ratio provides longer minimum time to failure because testing to higher % of SMYS

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