



# **KMAP<sup>TM</sup>**

## **for Longitudinal Weld Threat Analysis**

**H. Noel Duckworth**



# What is **KMAP**?

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- **K**inder **M**organ **A**ssessment **P**rotocol
- Advanced Data Analysis Process for Longitudinal Weld Threat Analysis
  - Developed In-House by KM Integrity Management Team
  - Patent Awarded
  - Employs Transverse Flux MFL Technology
  - Highly Disciplined, Thorough and Documented Process
  - Provides Process Auditable Archive
- A Filtering/Analytical Technique to Eliminate Non-Injurious Magnetic Anomaly Signals



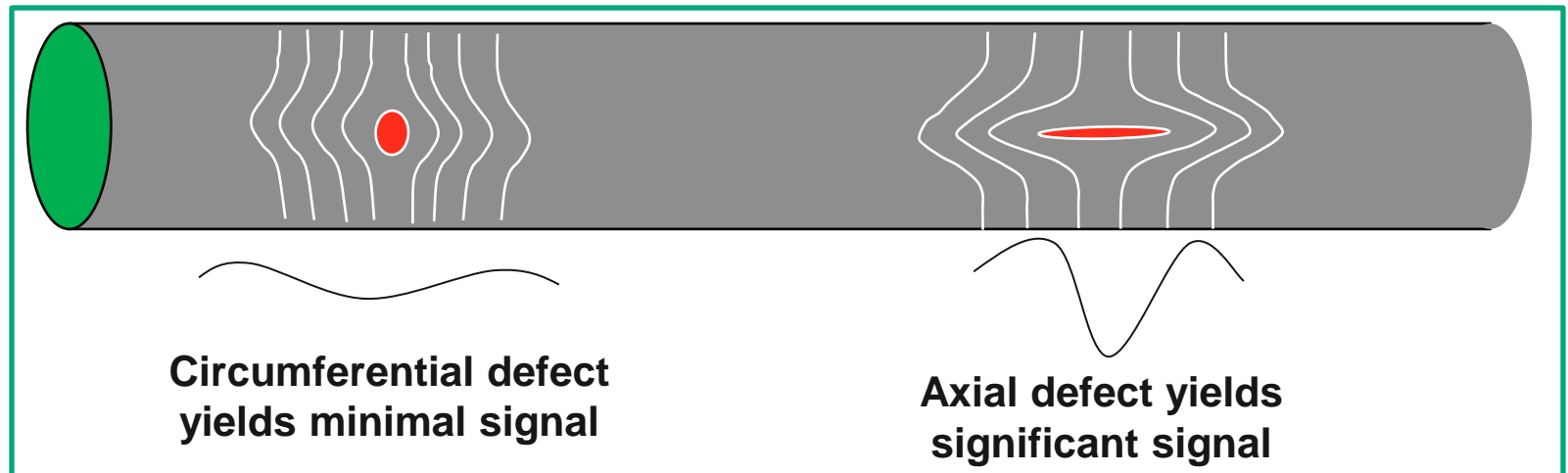
# KMAP Concept Origin

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- KM Release – Richmond, VA - 2006
  - Low-frequency welded Pre-1970 ERW
  - Cause of Failure – **Hook Crack** in Seam Weld
  - **Original Mill Defect** ~45% Penetration X 9.5" Long
  - Grew due to **Cyclic Fatigue** and **Hydrostatic Retesting**
  - Defect Just Prior to Failure ~**80% Penetration X 9.5" Long**
  - Failed at 990 psig (59.8 % of SMYS)
- ILI Surveys Performed Within A Few Months Prior to Release
  - Transverse Flux MFL
  - Shear Wave Ultrasonic
- Both data sets had a correlating anomaly. Neither considered it injurious primarily due to coincident presence of internal trim issues.

# KMAP Concept Origin Cont'd

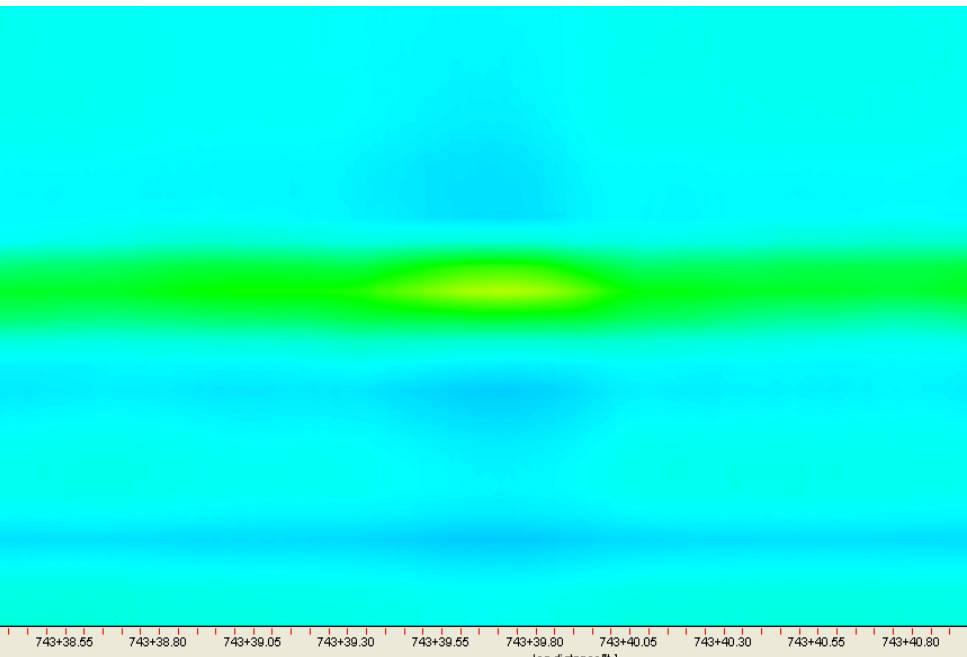
- KM Chose to Develop KMAP Using Transverse Flux MFL Technology



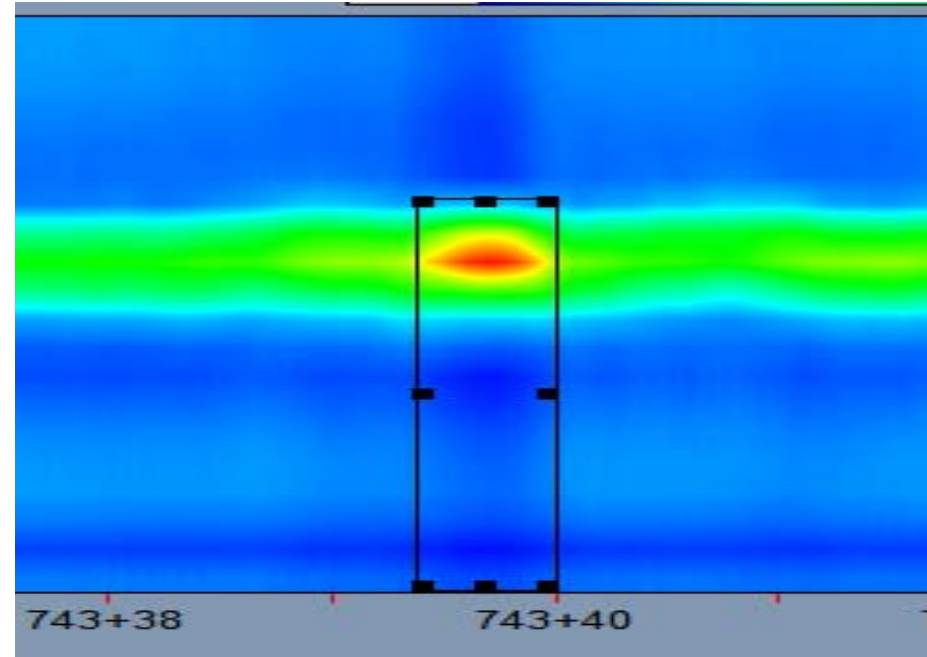
- Developmental and Continuing Prove-Up Has Proven KMAP to be Efficient and Effective
  - **Very Few False Positives**
  - **No Known False Negatives**

# CIRCUMFERENTIAL MFL DATA COMPARISON (ORIGIN DEFECT – RICHMOND, VA RELEASE)

## “C” Scan



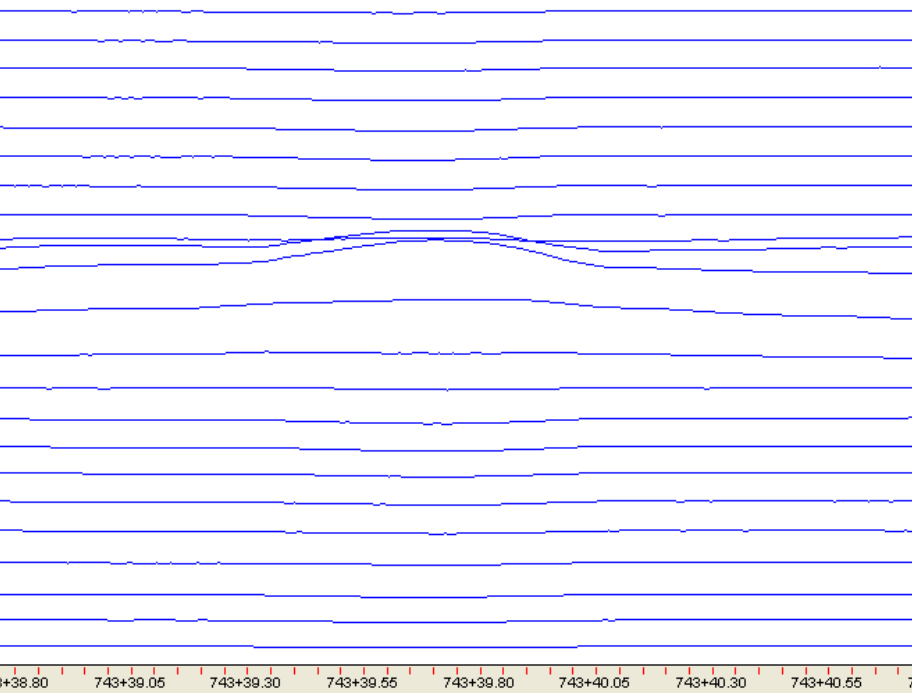
Normal Presentation  
for Metal Loss



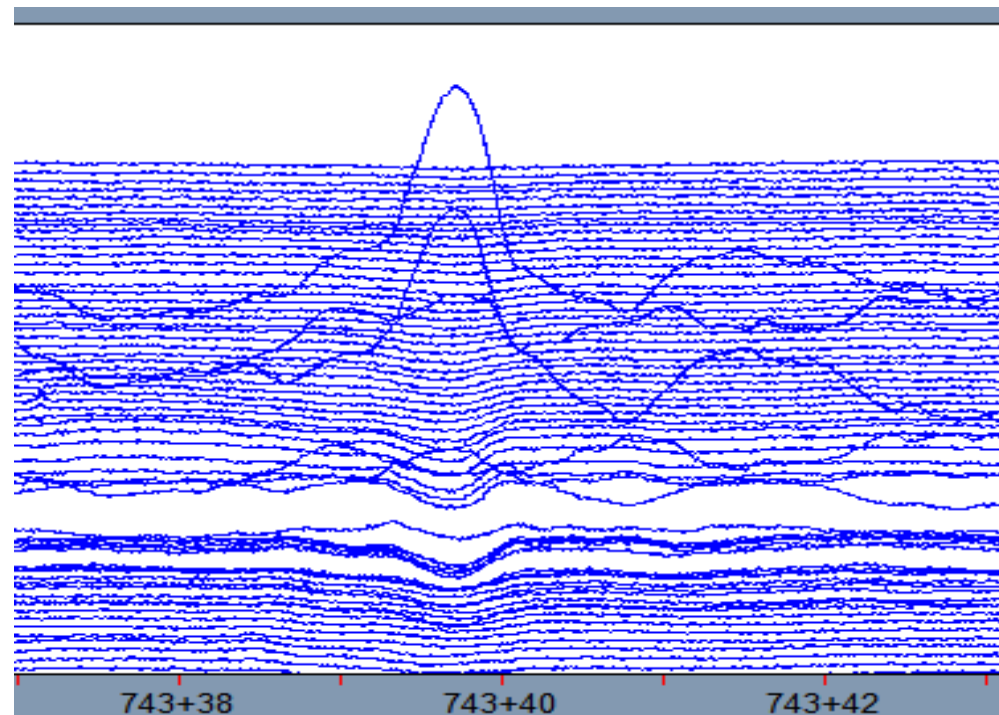
KMAP Graphic Optimized  
for Seam Weld Defects

# CIRCUMFERENTIAL MFL DATA COMPARISON (ORIGIN DEFECT – RICHMOND, VA RELEASE)

## “A” Scan



Normal Presentation for  
Metal Loss



KMAP Graphic Optimized  
for Seam Weld Defects



# Fitness for Purpose

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- Weld Seam Defect Detection With Flux Leakage:
  - The Minimum Detection Level is a Function of Air Gap
  - Air Gap is a function of Defect Dimensions, Pipe Properties, and Hoop Stress
- The Proven Minimum Detection Level is ~ 1" Long and 40% Penetration.
- In most Pipeline Steels this Minimum Detection Level, at an Operating Stress level of 72% SMYS, will be Adequate to Support a Reassessment Interval of 5 years....Even with Aggressive Cycling.



# KMAP and PHMSA

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- PHMSA audited the KMAP process as it was being developed and applied over several months under a CAO resulting from the Richmond, VA release. PHMSA's acceptance of the applied KMAP process provided assurance that the threat had been addressed. The CAO was lifted and the pipeline was allowed to be returned to full operating pressure.
- PHMSA, relying on their confidence gained in the instance stated above, declared KM compliant with a Compliance Order contained within a Final Order issued to KM for failing to consider low frequency ERW threats as per Part 195 and later, their related Advisory Bulletin.
- PHMSA, again relying on their prior experiences with KMAP, decreed that KM had complied with a "Return to Service" obligation under a CAO on our Platte P/L system and allowed it to be returned to full operating pressure. The Platte process utilized KMAP to identify anomalies for remediation.





# KMAP - Current Use at KM

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- Used on All KM Pipeline Systems Thought to Contain Longitudinal Welds Susceptible to Welding Defects or Selective Seam Corrosion.
- KM has utilized KMAP Analysis on approximately **8,000** miles of pipeline since 2006.
  - Performed Over 350 Digs Developing KMAP
  - **Since, has Remediated over 200 Injurious Seam Weld Defects solely based on KMAP.**



# KMAP Applied at KM

## Representative list of KMAP process results

P/L Segment Length (Mi)	124	96	103	130	106	68
Initial Magnetic Anomalies in Long. Seam	1552	2111	31064	6569	3419	1324
Remaining After Level 1 Filtering	529	701	4876	1495	1561	490
Remaining After Level 2 Filtering	165	277	1278	683	662	443
Remaining After Level 3 Filtering	130	267	360	602	615	426
Remaining After Level 4 Filtering	18	30	42	85	100	19
Remaining After Level 5 Filtering (Dug)	12	17	9	15	20	16
Injurious Defects Remediated	8	13	6	12	13	13
Success Rate % (70-80%=Optimum)	66.7	76.5	66.7	80.0	65.0	81.3



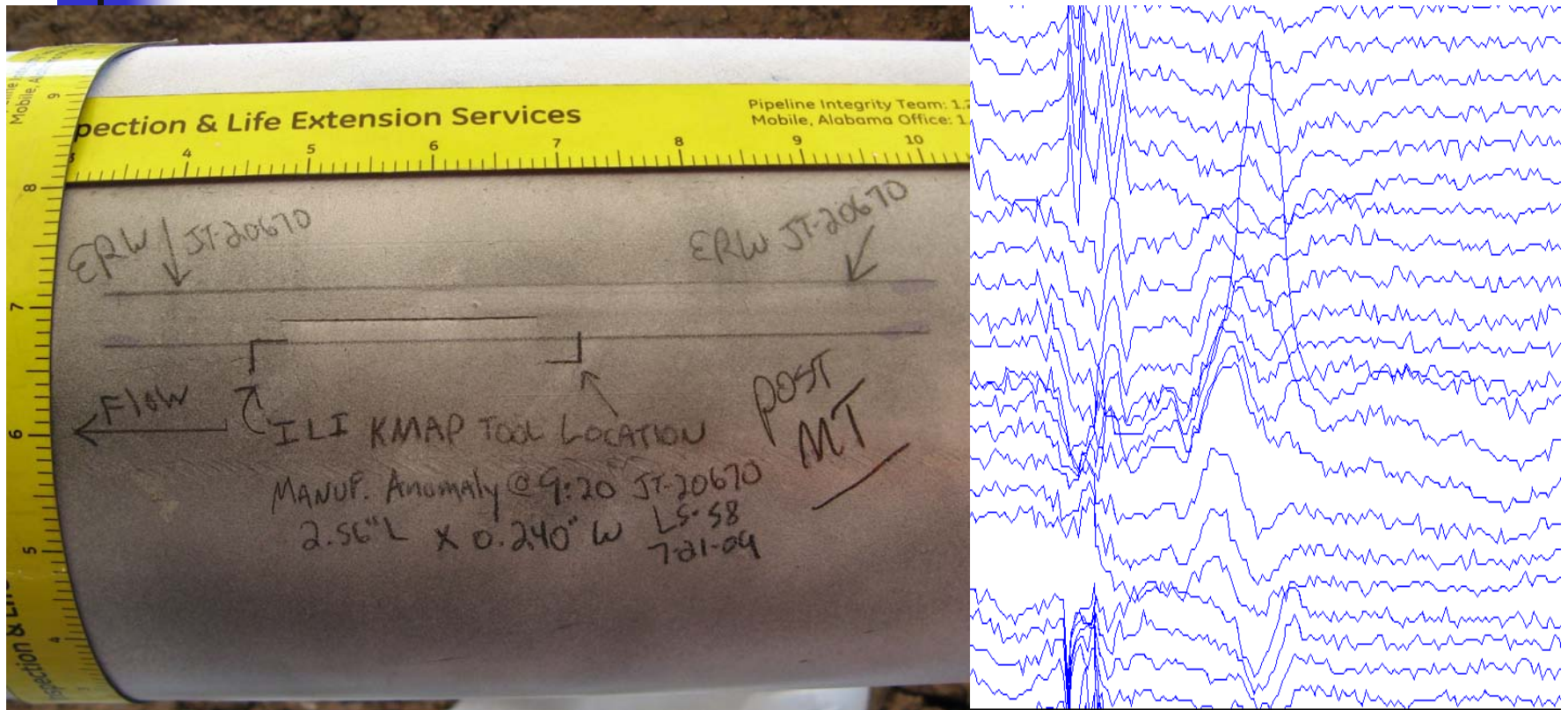
# Quality Assurance with KMAP

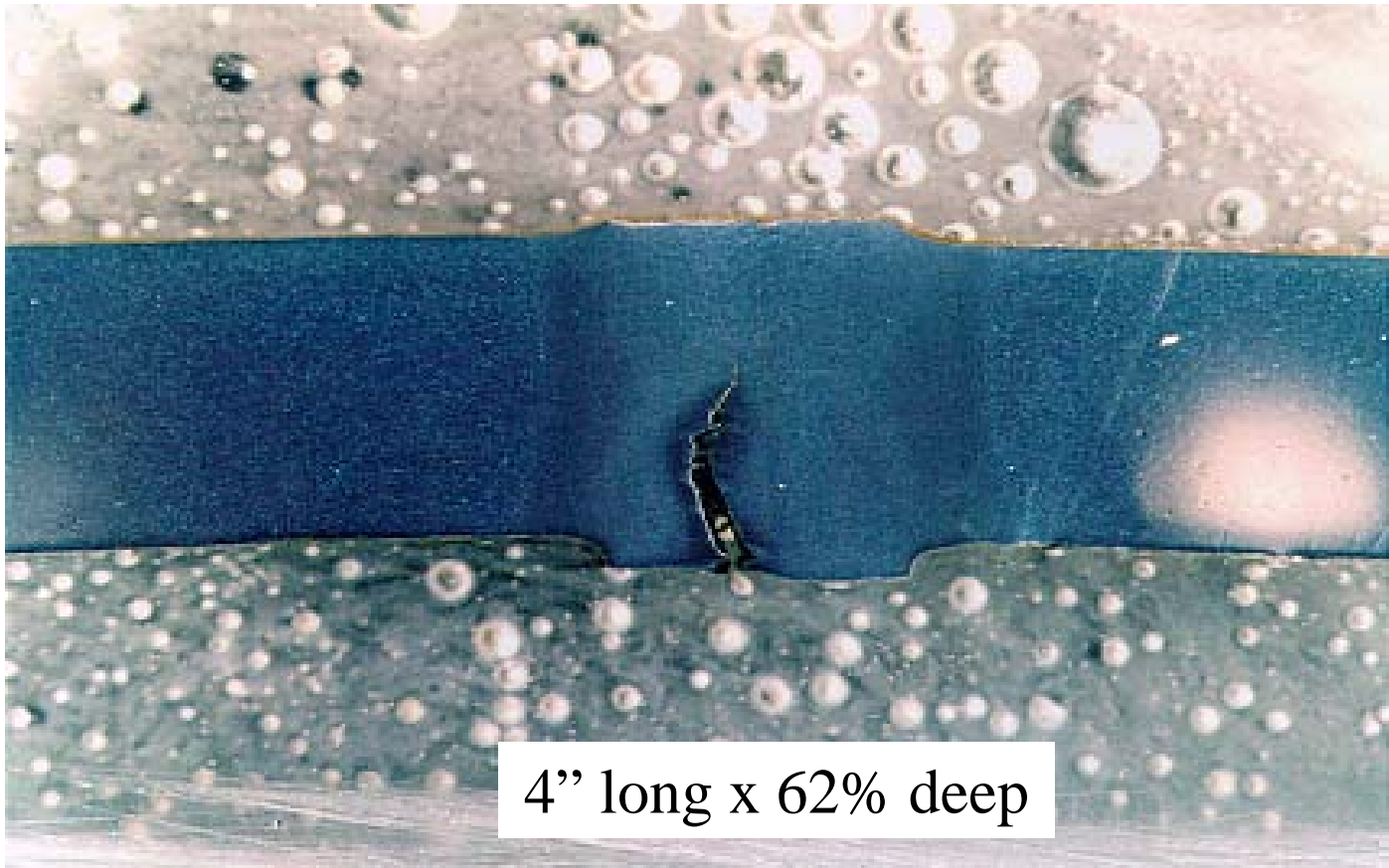
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- Level 5 Success Rate (cracks found vs. dug) should not exceed 85%. If higher, then KM chooses a representative sample of the most likely Level 4 anomalies to excavate. **(Assure Conservative Interpretation)**
- KM always investigates the longitudinal seam adjacent to the target anomaly to assure no additional defects exist. **(False Negative Assurance)**
- KM performs “Null-Digs” in areas where magnetic anomalies exist in the data that are not considered injurious defects by KMAP criteria. **(False Negative Assurance)**
- Post KMAP remediation, KM has performed random, short (5-10 mi) hydro tests in high defect density areas. **(Assure process adequacy)**
- A reassessment interval of 5 years has been determined to be more than adequate based on crack growth rate, minimum detection level, and critical flaw size.

# LF-ERW Hook Crack

(2.6" Long X ~70% Deep)







# What Now ?????

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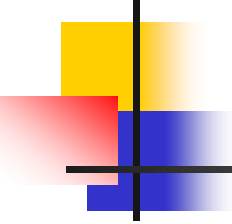
- **KM is Committed to the Sharing of its KMAP Technology with the Pipeline Industry on Some Reasonable Basis.**
- KM will continue to use the KMAP process on its pipeline systems and will strive to enhance its value under our “Continuing Improvement” initiatives.
- The Primary Purpose of this Presentation is to:
  - Openly Discuss the Technology and its History at KM.
  - Solicit input from Industry on how best to share the technology on an intelligent basis.
  - Express our Belief that Technology Enhancement can also be a shared endeavor.



# Possible Sharing Concepts

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- Technology Transfer/Training to Operating Entities
- KM Provide Analysis as a Service to Operators
- Train Consulting Firm(s) to Provide Service to Operators
- Combination of all of the Above
- Industry Supported Technology Enhancement Could be Beneficial to any/all of the Concepts Above



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# Questions ??

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