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# FIELD FAILURE ANALYSIS



TOOLS REQUIRED

## DESCRIPTION

THIS SECTION OF THE DESIGN & ENGINEERING HANDBOOK WILL PROVIDE GUIDELINES FOR ANALYZING BROKEN PLASTIC PARTS.

## CAUSES OF PLASTIC FAILURE

- PART DESIGN
- MATERIAL INTEGRITY
- CHEMICAL ATTACK
- EXCESSIVE PERFORMANCE REQUIREMENTS
- ENVIRONMENT

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## ***FIELD FAILURE ANALYSIS: CHECKLIST***

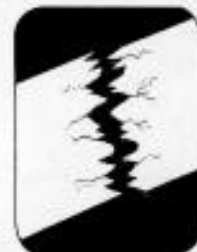
- PRESERVE THE FAILED PART
- DETERMINE MATERIAL INTEGRITY
  - IF UNACCEPTABLE, FURTHER FAILURE ANALYSIS SHOULD BE ABANDONED. CORRECTION OF PROCESSING CONDITIONS SHOULD IMPROVE MOLDED PART PERFORMANCE.
- LOCATE FRACTURE ORIGIN USING
  - CRACK BRANCHING
  - RIVER MARKING
  - SUSPECT AREAS CHART
- IF POSSIBLE MODIFY DESIGN TO REMOVE SUSPECT AREA CHARACTERISTIC

### **OBTAIN EASTMAN ASSISTANCE IF...**

- CHEMICAL ATTACK SUSPECTED
- ENVIRONMENTAL FAILURE SUSPECTED
- EXCESSIVE PERFORMANCE REQUIREMENT FAILURE SUSPECTED
- THOROUGH ANALYSIS DESIRED

### **IN DETAIL...**

THE DESIGN & ENGINEERING HANDBOOK PROVIDES A DETAILED DESCRIPTION OF EACH OF THESE CHECKLIST STEPS. FOLLOWING THESE GUIDELINES SHOULD ENSURE A THOROUGH FIELD FAILURE ANALYSIS.



# ***FIELD FAILURE ANALYSIS: MATERIAL INTEGRITY***

## **INHERENT VISCOSITY**

THE INHERENT VISCOSITY (IV) OF A POLYESTER MATERIAL MAY BE DETERMINED THROUGH A SOLUTION TEST OR THROUGH A GEL PERMEATION CHROMATOGRAPHY (GPC) TEST. THE IV OF A MOLDED PART IS AN INDICATOR OF THE AVERAGE MOLECULAR WEIGHT OF A MATERIAL. THE MOLECULAR WEIGHT OF A MATERIAL DETERMINES PHYSICAL PROPERTIES SUCH AS, TENSILE STRENGTH, STIFFNESS AND IMPACT PERFORMANCE.

## **PROCESSING AND IV**

PROCESSING POLYESTER-BASED MATERIALS WILL REDUCE THE IV. IF DRYING AND PROCESSING GUIDELINES ARE FOLLOWED, THE IV OF THE MOLDED PART WILL EXHIBIT ONLY A SLIGHT DROP. IMPROPER DRYING, EXCESSIVE RESIDENCE TIMES, EXCESSIVE TEMPERATURES OR EXCESSIVE USE OF REGRIND MATERIALS MAY CAUSE UNACCEPTABLE DROPS IN IV, REDUCING THE PROPERTIES OF THE MATERIAL.

## **DETERMINE MATERIAL INTEGRITY**

EASTMAN TECHNICAL SERVICE LABS ARE AVAILABLE TO ASSIST IN THE TESTING OF MOLDED PARTS. ONE OF THE FIRST STEPS IN ANY FAILURE ANALYSIS SHOULD BE A DETERMINATION OF THE MATERIAL INTEGRITY. SUBMIT FAILED PART AND IF POSSIBLE A SAMPLE OF PELLETS FROM THE MATERIAL LOT IN QUESTION TO EASTMAN TECHNICAL SERVICE LABS.



# **FIELD FAILURE ANALYSIS: FRACTURE ORIGIN**

## **BACKGROUND**

LOCATION OF THE FRACTURE ORIGIN SHOULD IDENTIFY THE TYPE OF FAILURE. FOLLOWING THE CHECKLIST SUGGESTED IN THE DESIGN & ENGINEERING HANDBOOK SHOULD HAVE ALREADY DETERMINED THE MATERIAL INTEGRITY IS ACCEPTABLE, THERE REMAIN SEVERAL POTENTIAL FAILURE TYPES. (REFER TO "CAUSES OF PLASTIC FAILURE")

INFORMATION AT THE FRACTURE ORIGIN SHOULD PROVIDE A SMALLER LIST OF POTENTIAL FAILURE TYPES.

## **HOW TO LOCATE THE ORIGIN**

THIS SECTION WILL PROVIDE FRACTURE ANALYSIS TECHNIQUES THAT SHOULD ALLOW YOU TO IDENTIFY THE FRACTURE ORIGIN. DETERMINATION OF THE PRECISE INITIAL FRACTURE SITE MAY STILL BE POSSIBLE WITHOUT MICROSCOPY.

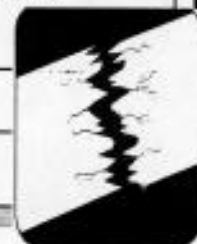
## **LOCATE THE INITIAL FRACTURE SITE**

1. FOLLOW RIVER MARKINGS AND CRACK BRANCHING TO GENERAL AREA OF SUSPECTED INITIATION SITE.
2. FURTHER PINPOINT SITE THROUGH SEARCH OF IMMEDIATE VICINITY FOR "SUSPECT AREAS".
3. MENTALLY RECREATE THE MOVEMENT OF THE INITIAL FRACTURE SITE DURING THE IMPACT. IMPACT FAILURES ARE TYPICALLY A TENSILE TYPE FAILURE.

## **IF THESE METHODS FAIL TO PINPOINT THE INITIAL FRACTURE CAUSE...**

A MORE EXTENSIVE FAILURE ANALYSIS SHOULD BE PERFORMED. CONTACT YOUR NEAREST EASTMAN REPRESENTATIVE.

**NOTES CONTINUED ON NEXT PAGE**



## ***FIELD FAILURE ANALYSIS: FRACTURE ORIGIN CONT.***

### **IF THE INITIAL FRACTURE SITE IS LOCATED...**

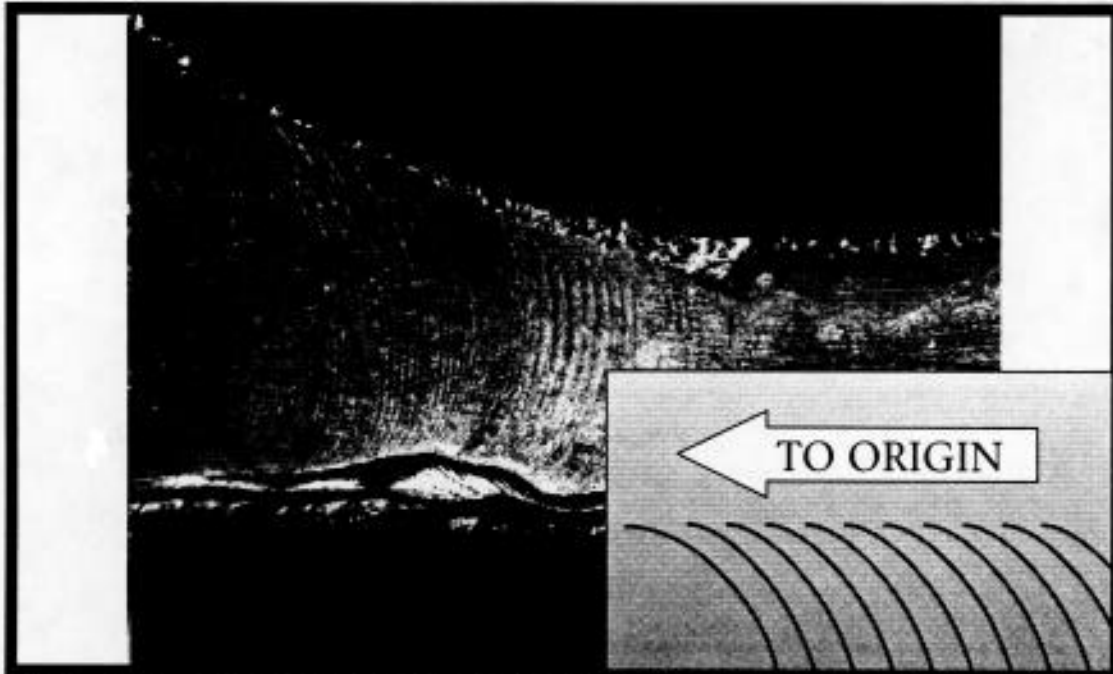
MOST FAILURE ANALYSIS CASES MAY BE ALLEVIATED THROUGH DESIGN CHANGES AT THE INITIAL FRACTURE SITE.

### **ONCE INITIAL FRACTURE SITE IS LOCATED**

REMOVAL/MODIFICATION OF THE "SUSPECT AREA" (SHARP NOTCH, SUDDEN THICKNESS CHANGE, ETC.) MAY ALLEVIATE OR ELIMINATE THE FAILURES. HOWEVER, IT IS STILL POSSIBLE THAT THE PART FAILURE OCCURS DUE TO CHEMICAL ATTACK, EXCESSIVE PERFORMANCE REQUIREMENTS, OR AN ENVIRONMENTAL CONDITION, SUCH AS A LOW TEMPERATURE FAILURE. THESE EFFECTS ARE TYPICALLY MORE DIFFICULT TO DIAGNOSE AND TO CORRECT.



## ***FIELD FAILURE ANALYSIS: FRACTURE ORIGIN***

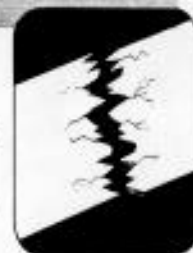


### **RIVER MARKS**

RIVER MARKS ARE TYPICALLY VISIBLE ON THE FRACTURE EDGE. A MAGNIFYING LENS SHOULD ASSIST IN LOCATION OF THESE MARKINGS. THE PATTERN SHOWN IN THE INSET ILLUSTRATES THE RIVER MARKINGS POINTING TOWARD THE FRACTURE ORIGIN.

USE A PERMANENT MARKER TO PLACE ARROWS ON THE PART WHERE THE RIVER MARKINGS INDICATE ORIGIN DIRECTION. FOLLOW THE RIVER MARKINGS THROUGH EACH CRACK AS THEY MAY CHANGE DIRECTION AT CRACK INTERSECTIONS.  
AFTER VIEWING ALL RIVER MARKINGS AND LABELLING THEM WITH ARROWS FOLLOW THE ARROWS LOOKING FOR SUSPECT AREAS.

**NOTES CONTINUED ON NEXT PAGE**



## ***FIELD FAILURE ANALYSIS: FIRST STEP***

### **CRITICAL FIRST STEP**

- **PRESERVE THE FAILED PART!** FAILURE ANALYSIS REQUIRES ALL OF THE PIECES OF THE PART.
- DO NOT CLEAN THE PART AS THIS MAY DESTROY VALUABLE INFORMATION.
- DO NOT ALLOW THE PART TO BE BROKEN FURTHER OR FLEXED. THIS MAY OBSCURE THE INITIAL FRACTURE INFORMATION.
- PHOTOGRAPH PART IF DOCUMENTATION OF FAILURE ANALYSIS IS REQUIRED.

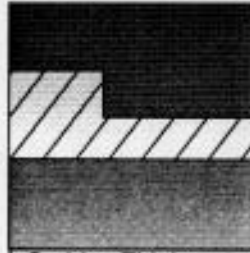


# FIELD FAILURE ANALYSIS: FRACTURE ORIGIN CONT.

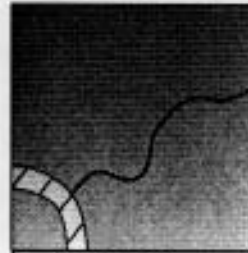
## SUSPECT AREAS



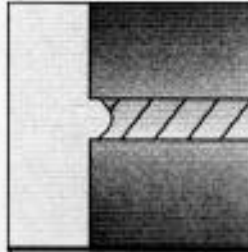
Sharp Notch



Sudden Thickness Changes



Weld Line



Adhesive Joints



Secondary Assemblies

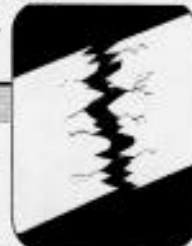
## NOTE

RIVER MARKINGS MAY BE DIFFICULT TO LOCATE IN FILLED MATERIALS.

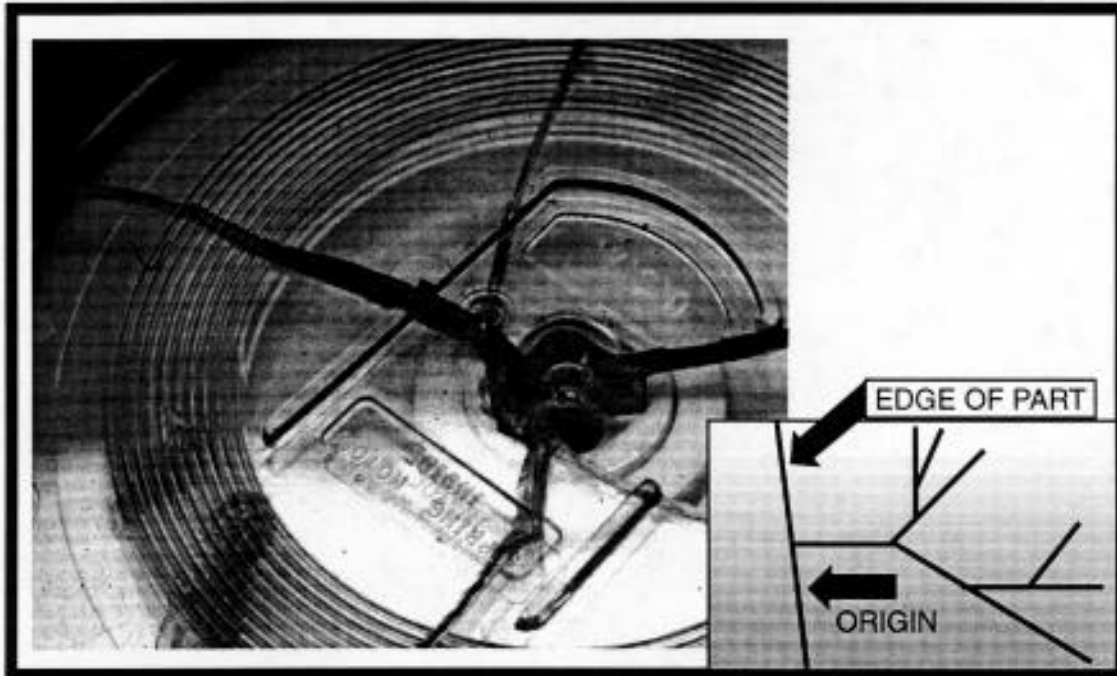
## CONCLUSION

OBSERVING CRACK BRANCHING AND RIVER MARKINGS SHOULD ALLOW APPROXIMATE LOCATION OF THE INITIAL FRACTURE SITE. THE SITE SHOULD BE ONE OF THE SUSPECT AREAS. OTHER FRACTURE MARKINGS MAY HELP PINPOINT THE PRECISE INITIATION POINT. MICROSCOPY ALLOWS A CLOSER LOOK AT THE FRACTURE INITIATION POINT.

NOTES CONTINUED ON NEXT PAGE



## FIELD FAILURE ANALYSIS: FRACTURE ORIGIN CONT.



### BRANCHING

LOOK FOR CRACKS ON THE FAILED PART. THE CRACKS THAT END INTERNALLY ARE AWAY FROM THE ORIGIN. THESE CRACKS TYPICALLY EXHIBIT A GREAT DEAL OF BRANCHING.

BRANCHING FRACTURES SHOULD PROVIDE A *GENERAL* LOCATION FOR THE FRACTURE ORIGIN. FOLLOWING **RIVER MARKINGS** SHOULD HELP PINPOINT THE ORIGIN.



# ***FIELD FAILURE ANALYSIS: CHEMICAL ATTACK***

## **EVALUATION OF A POTENTIAL ENVIRONMENTAL FAILURE**

EVALUATION OF A POTENTIAL CHEMICAL ATTACK FAILURE REQUIRES A MORE EXTENSIVE FAILURE ANALYSIS. TWO OPTIONS ARE AVAILABLE:

- FRACTURE LAB ANALYSIS
- CHEMICAL RESISTANCE TESTING

EASTMAN MAINTAINS AN EXTENSIVE FRACTURE LAB THAT MAY CONTINUE THE ANALYSIS THROUGH MICROSCOPY AND MORE ADVANCED TECHNIQUES.

EASTMAN TYPICALLY PERFORMS CHEMICAL RESISTANCE TESTING UNDER STRESSED AND UNSTRESSED CONDITIONS.



## ***FIELD FAILURE ANALYSIS: EXCESSIVE PERFORMANCE REQUIREMENTS***

SEVERAL TECHNIQUES ARE AVAILABLE TO DETERMINE IF A PART FAILED DUE TO EXCESSIVE STRESS.

### **EVALUATION OF A POTENTIAL ENVIRONMENTAL FAILURE**

FINITE ELEMENT MODELING CAN PROVIDE AN ACCURATE ESTIMATE OF RESULTANT STRESS WITHIN THE PART. THIS STRESS MAY BE COMPARED TO YIELD STRESS VALUES TO EVALUATE THE PERFORMANCE REQUIREMENTS OF THE PART.

### **STRAIN GAGE ANALYSIS**

EASTMAN HAS A COMPUTERIZED STRAIN GAGE TEST MACHINE. THE MACHINE CAN PROVIDE ACCURATE MEASUREMENTS OF STRAIN ON AN EXISTING PART IN ITS END USE FUNCTION.



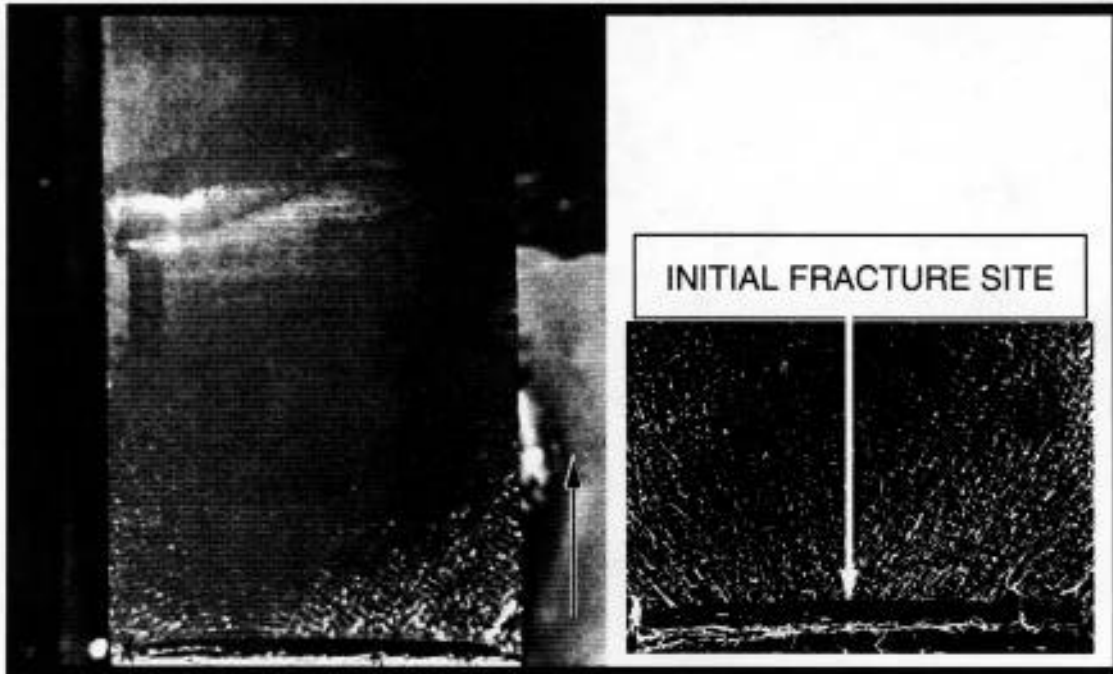
## ***FIELD FAILURE ANALYSIS: ENVIRONMENTAL FAILURE***

### **EVALUATION OF A POTENTIAL ENVIRONMENTAL FAILURE**

EASTMAN HAS FACILITIES TO PERFORM MOST ENVIRONMENTAL TESTING. ENVIRONMENTAL EFFECTS TYPICALLY DO NOT LEAVE PHYSICAL EVIDENCE ON THE BROKEN SAMPLES. IT IS NOT POSSIBLE TO EVALUATE FAILURES OF THIS TYPE WITHOUT LABORATORY TESTING. CONTACT AN EASTMAN REPRESENTATIVE.



# WALLNER LINES



## CRITICAL CONSTRAINTS

- WAVELIKE BANDS THAT MAY RADIATE FROM THE FRACTURE ORIGIN.
- CREATED BY INTERACTION OF THE PROPAGATING CRACK FRONT WITH A TRANSVERSE ELASTIC IMPULSE, CAUSING A MOMENTARY DEVIATION OF THE CRACK FRONT.
- MAY BE OBSERVED WITHOUT MAGNIFICATION.

## NOTES

- NOT TYPICALLY OBSERVED WITH FILLED MATERIALS.
- VERY USEFUL IN PINPOINTING INITIAL FRACTURE SITE.

