

# Introduction to Welding Discontinuities and Defects

PRESENTED BY: NICK DUPONT

# Introduction

- ▶ Name: Nick DuPont
- ▶ Little About me and my Background:
  - ▶ Born and raised in Escanaba, Michigan
  - ▶ Avid outdoorsmen and motorsports enthusiast
  - ▶ Education:
    - ▶ Welding Certificate from Bay College (2009)
    - ▶ AAS Welding Technology from Ferris State University (2011)
    - ▶ BS Welding Engineering Technology from Ferris State University (2013)
  - ▶ Certifications:
    - ▶ American Society for Nondestructive Testing (ASNT) Certified VT Level III
    - ▶ American Welding Society (AWS) Certified Welding Inspector (CWI)
  - ▶ Have been a Welding Engineer and Nondestructive Testing Examiner working in the following fields:
    - ▶ New construction and repair of ships and barges
    - ▶ Hydroelectric Industry
    - ▶ Paper mill industry
    - ▶ Welding Program Lead for Bay College ([Bay College Welding Program Link](#))

# Presentation Purpose

There are dozens of discontinuities and defects to learn in the welding world. Many of which are specific to certain types of welding processes. Being able to accurately identify discontinuities and defects as well as their root cause is an essential part of becoming a competent welder. This presentation is meant to start students down that path.

# Topics

- Key Terms
  - Indication
  - Discontinuity
  - Defect
- Causes and Solutions for Discontinuities and Defects
  - Spatter
  - Porosity
  - Cold roll
  - Undercut
  - Lack of fusion
  - Arc Strikes
  - Inclusions
  - Cracking
- Recommended Books

# Key Terms

- Indication
  - A nondestructive testing response that requires interpretation to determine its relevance (discontinuity vs. defect).
- Discontinuity
  - An intentional or unintentional interruption in the physical structure or configuration of a part. A discontinuity is not necessarily a defect.
- Defect
  - A condition or discontinuity having a size, shape, orientation, nature, frequency, or location that impairs the useful service of the part and is rejectable to a specification, standard, or code. A defect is a rejectable discontinuity.

# Spatter

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## Causes

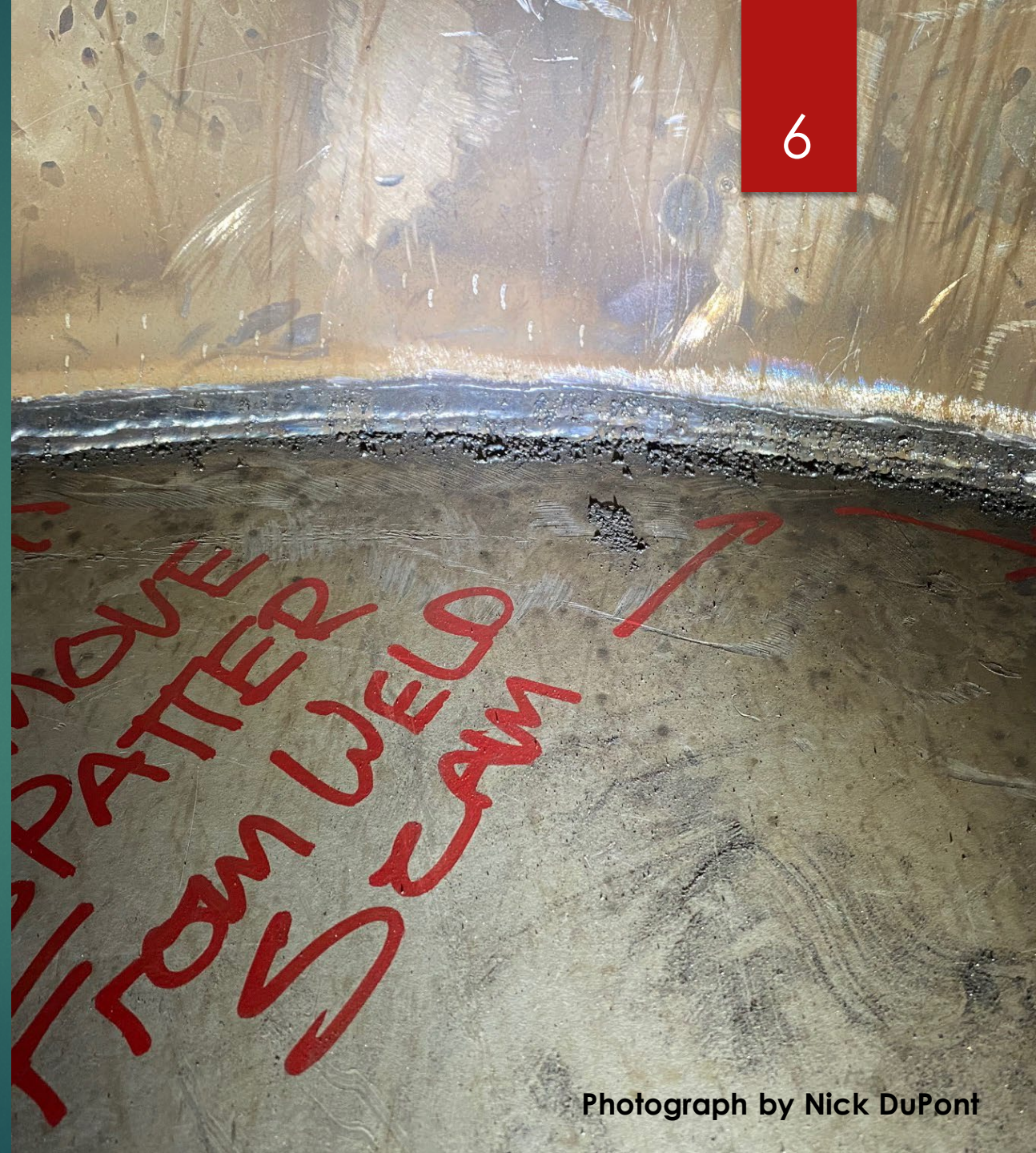
- Improper welding parameters (high wire feed speeds) and or technique.
- Long arc lengths.
- Shielding gas selection and settings (if applicable).
- Welding through contaminants.

## Simple steps to avoid spatter

- Proper welding parameters.
- Proper welding technique.
- Ensure the correct shielding gas is being used and that the flow settings are correct.

## Proper repair procedure

- Grinding or scraping to remove spatter to within an acceptable limit.



Photograph by Nick DuPont

# Porosity

## Causes:

- Contamination.
- Loss of Shielding Gas (if applicable).

## Simple steps to avoid porosity:

- Proper cleaning of base materials.
- Using new or properly stored filler materials.
- Checking for gas leaks (if applicable).

## Proper repair procedure:

- Grinding out the affected area and rewelding when the root cause has been resolved.



# Internal Porosity

What would you say the root cause was for the porosity in this photograph.

**PRIMER!**

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Photograph by Charles Valitchka Jr.  
Used with permission.

# Cold Roll

## Causes:

- Improper welding parameters.
- Welding technique.

## Simple Steps to Avoid Cold Roll:

- Ensure that welding procedures are being followed, especially pay attention to voltage.
- Position yourself for the proper work and travel angles

## Proper repair procedure

- Grinding down the excessive reinforcement. If the weld size has been reduced below what is required, add weld.

NOTE: Washing of a weld face should be avoided in most cases.



# Undercut

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## Causes:

- Too high of welding parameters
- Inadequate addition of filler metal
- Incorrect work angle
- Too fast of travel speed

## Simple steps to avoid undercut:

- Follow the proper welding procedures.
- Practice proper work angles
- Slow the travel speed and ensure that enough filler metal is being added to replace the base material that is being melted away.

## Proper repair procedure:

- Slight grinding the affected area to make a uniform groove and add weld.



# Lack of Fusion (LOF)

## *Fillet Weld Toes*

### Causes:

- Welding technique.
  - Improper work angle.
- Incorrect welding parameters.
  - Too cold of settings.

### Simple steps to avoid LOF:

- Ensure that you're are positioned to view the weld area as good as possible.
- Increase welding parameters.

### Proper repair procedure:

- Grinding out the affected area and rewelding when the root cause has been resolved.



# Lack of Fusion (LOF)

## *Fillet Weld Root*

### Causes

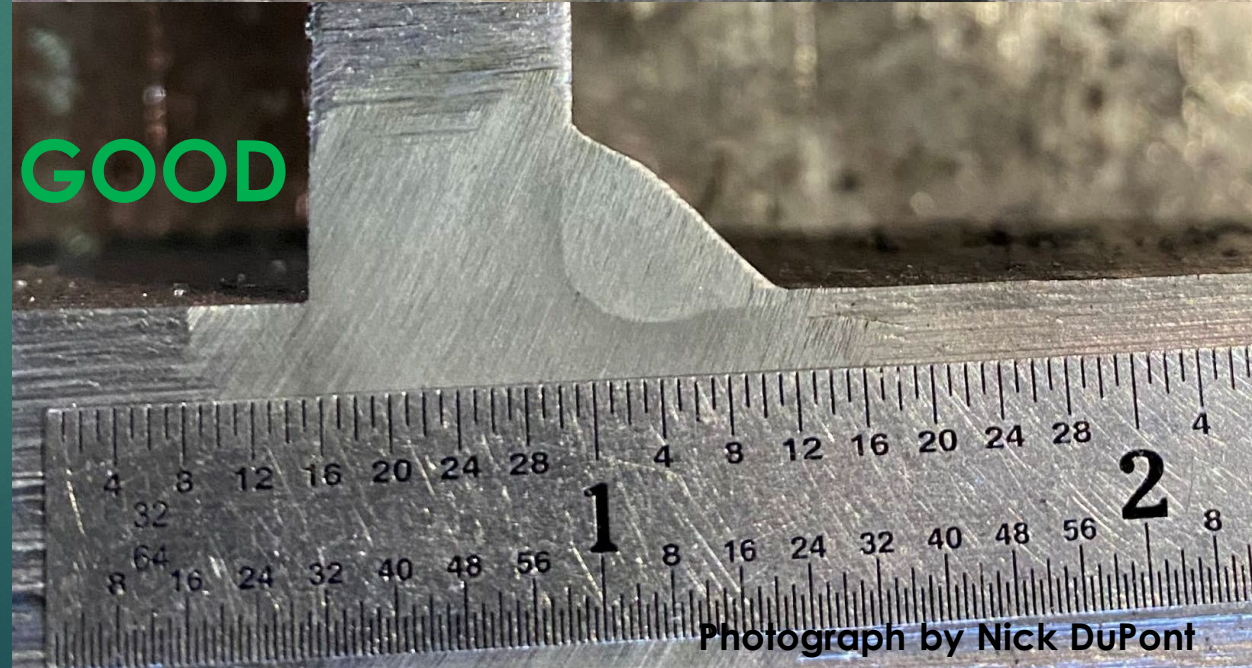
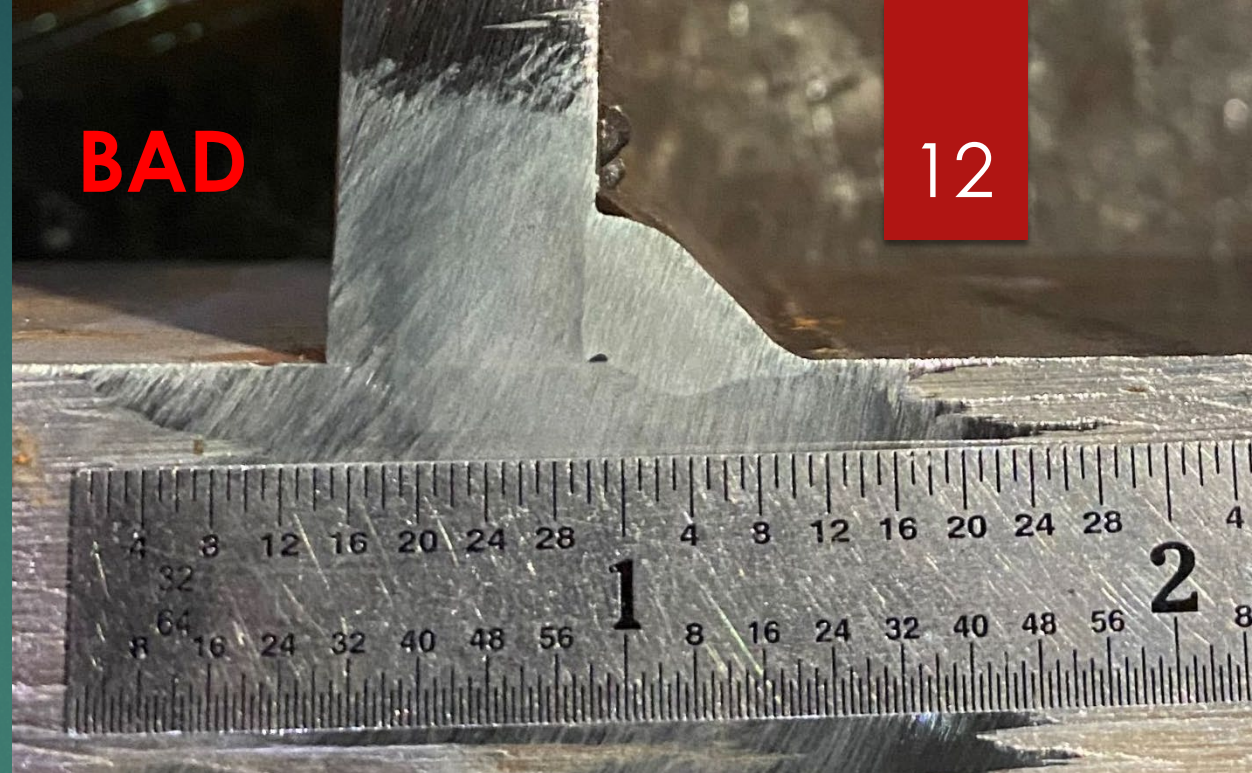
- Welding technique.
  - Improper work and/ or travel angle.
  - Push vs Drag
- Incorrect welding parameters.

### Simple steps to avoid LOF

- Practice proper torch and work angle.
- Ensure that the welding parameters are set within the procedure limits.

### Proper repair procedure

- Complete removal weld down to the root followed by rewelding using proper technique and parameters.



# Lack of Fusion (LOF) Groove Welds

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## Types

- Lack of side wall fusion
  - Weld not fused to the prepared bevel.
- Lack of interbead fusion
  - Weld not fused to previous weld beads
- Incomplete joint penetration
  - The prepared root edge of the bevel has not been consumed by the weld.

## Causes

- Welding joint preparation
- Incorrect welding parameters

## Simple steps to avoid LOF

- Ensure that you're are positioned to view the weld area as best as possible.

## Proper repair procedures

- Grinding out the affected area and rewelding when the root cause has been resolved.

# Arc Strikes

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## Causes

- 100% welder error

## Simple steps to avoid arc strikes

- Proper disengagement of the stick electrode from the electrode holder (SMAW).
- Stop current to the tig torch if/ when the tungsten sticks before breaking it free (GTAW)
- Ensure work leads (grounds) are secure and not able to slip.

## Proper repair procedures

- Must be ground out and complete a weld repair if needed.



# Arc Strike

## Continued

Cracking in areas of an arc strike after completing a bend test.

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Photograph by Charles Valitchka Jr.  
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# Inclusions Slag

## Causes:

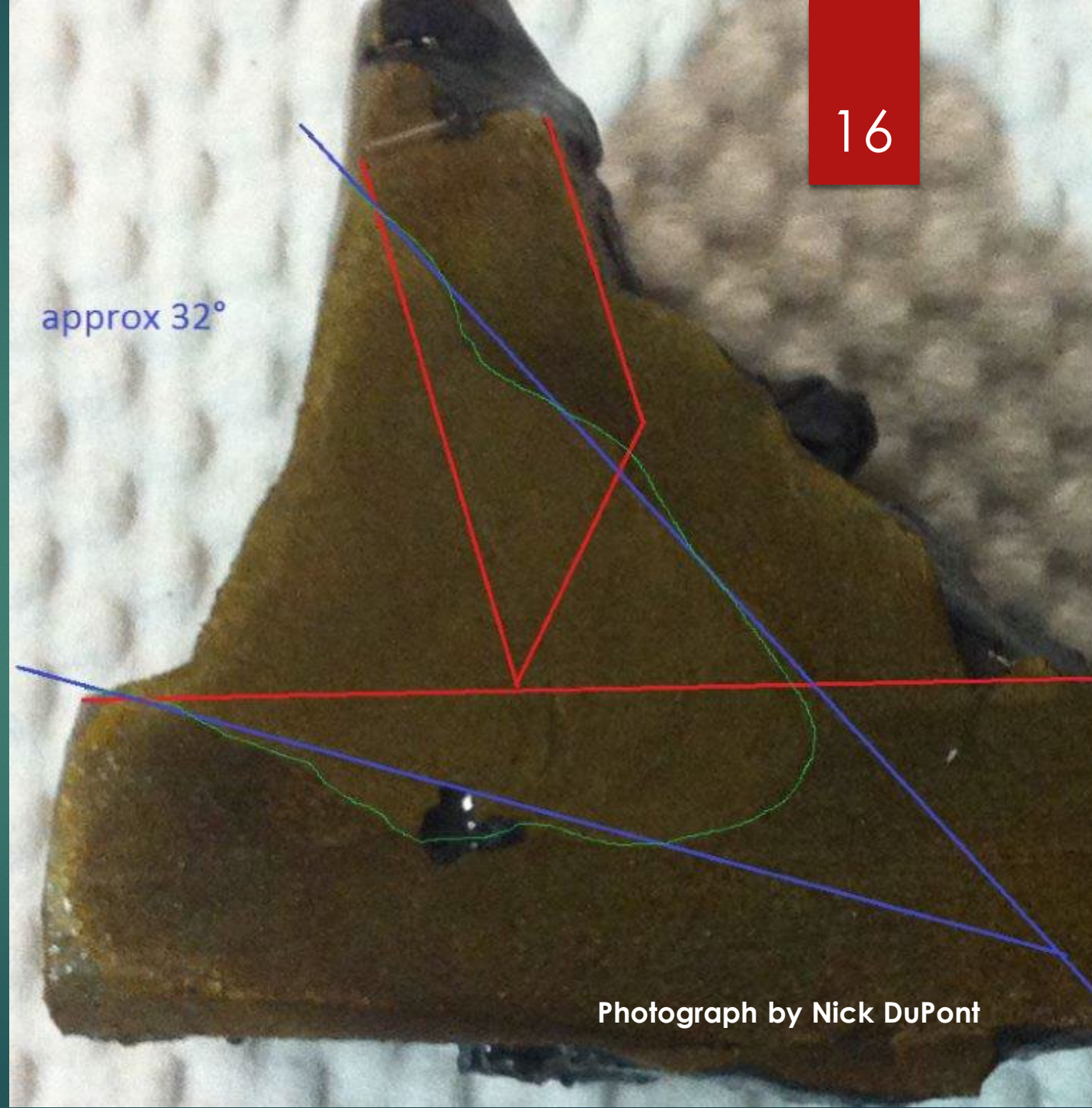
- Improper welding technique.
  - Drag vs Push.
- Improper weld joint preparation.

## Simple steps to avoid slag inclusion:

- Avoid narrow deep grooves.
- Drag slag producing processes
- Ensure proper travel speeds are being used.

## Proper repair procedure:

- Must be gouged and/ or ground out and reweld with proper weld joint preparation and welding technique.



# Inclusions

## Tungsten

Processes applicable to this type of discontinuity are GTAW and PAW

Cause:

- Dipping the tungsten into the weld pool or filler metal during welding
- Sticking the tungsten weld or base material followed by breaking the tungsten free.
- Using welding currents that exceed the tungsten's rating.

Ways to avoid tungsten inclusions:

- Practicing proper welding techniques such as maintaining a proper and consistent arc length.
- Always operate within the ratings for the tungsten type and size being uses.
  - This should be detailed in the welding procedure.

Proper repair procedure:

- The inclusion must be ground completely and rewelded.

# Cracking

Cracking can occur in welds for several reasons. The more commonly known types of weld cracking include the following:

- Longitudinal Crack
- Transverse Crack
- Crater Crack
- Hydrogen Induced Cracking
  - Toe crack
  - Underbead crack
  - Delayed cracking

# Longitudinal Cracking

Longitudinal cracking, also commonly referred to as “hot cracking” and “centerline cracking”, is typically a result of one of the following conditions:

- Insufficient root weld throat.
- High depth to width ratio welds.
- Alloy segregation of low melting point elements during weld solidification.

How to avoid longitudinal cracking:

- Adequate weld metal being added to the weld bead (especially during the root pass)
- Ensure that groove weld joints are being beveled to fit-up correctly.
- Preheating weld joints to help slow the cooling rate and reduce shrinkage stresses.
- Use a weld sequence that will help distribute stress more evenly.

Proper repair Procedure:

- The crack must be completely removed via gouging or grinding.

# Transverse Cracks

## Causes:

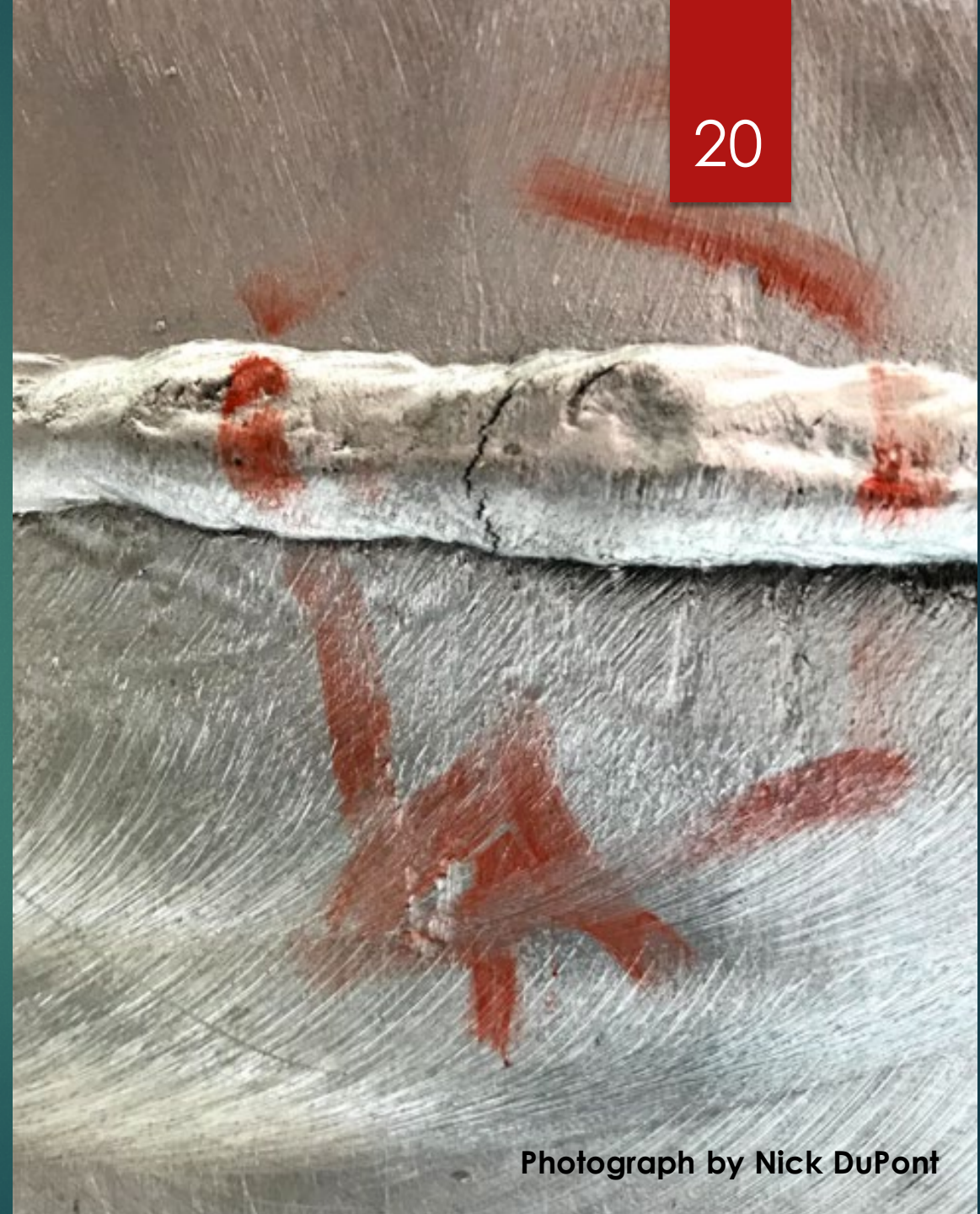
- High longitudinal stress on the weld as it solidifies.
- Can occur when the filler metal has substantially higher strength than the base material being welded.
- Potentially hydrogen induced.

## Simple steps to avoid transverse cracks:

- **Do not** over match filler metal.
- Complete welding with as little restraint as possible
- Ensure hydrogen sources are limited
- Preheating to reduce shrinkage stresses and allow more time for hydrogen defusal.

## Proper repair procedure:

- Must be completely gouged and/ or ground out and rewelded with proper weld joint preparation and welding technique.



# Crater Cracks

## Causes:

- Premature termination of the arc. The throat of the crater is too thin to withstand surrounding base materials resistance to the weld's shrinkage force.

## Simple steps to avoid crater cracking:

- Fill the crater of the weld to the point that it matches the throat of the rest of the weld.

## Proper repair procedure:

- Grind to sound weld metal before continuing welding.



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# Hydrogen Induced Cracking (HIC)

## Causes:

- Too high of hydrogen source.
- Susceptible microstructure, such as martensite.
- High stress.

## Simple steps to avoid HIC:

- Preheating to slow the cooling rate allowing for hydrogen to diffuse out of the weld and heat affected zone.
- Use a low hydrogen welding process.

## Proper repair procedure:

- The crack must be completely removed via gouging or grinding followed by rewelding procedures designed for welding material prone to HIC.



# Hydrogen Induced Cracking

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Photograph by Nick DuPont

# Hydrogen Induced Cracking Prevention

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Low hydrogen welding process  
and/ or electrodes

- Ex. E7018 or 7018 H4R

Time frame to use electrodes

- Typically 4 hrs. for 7018.
- Up to 9 hrs. for 7018 H4R

Electrode Storage

- Stored in an oven at 250°F for  
at least 4 hours after 4 hours  
of atmospheric exposure.

The above information is from AWS D1.1.

[Hydrogen Diffusing from Weld Metal - YouTube](#)

[The Role of Hydrogen in the Welding of Steel – YouTube](#)



Photograph by Nick DuPont

# Final Takeaways

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Key terms to remember when welding and evaluating welds (indication, discontinuity, and defect).

Discussed several of the most common welding discontinuities and defects.

- Spatter
- Porosity
- Cold roll
- Undercut
- Lack of fusion
- Arc Strikes
- Inclusions
- Cracking

Often, correcting these issues are simple adjustments in technique, and ensuring procedures are being followed.

# Personal favorite welding books

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- ▶ The Procedure Handbook of Arc Welding by Lincoln Electric
  - ▶ [Procedure Handbook "Fourteenth Edition" \(jfff.org\)](http://jfff.org)
- ▶ Design of Weldments by Omer W. Blodgett
  - ▶ [Design of Weldments \(jfff.org\)](http://jfff.org)
- ▶ Welding Aluminum Questions and Answers by Tony Anderson
  - ▶ [AWS Bookstore. WQA 2nd EDITION: WELDING ALUMINUM - QUESTIONS AND ANSWERS - A PRACTICAL GUIDE FOR TROUBLESHOOTING ALUMINUM-RELATED PROBLEMS](http://awsbookstore.com)
- ▶ AWS A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination by the American Welding Society.
  - ▶ [AWS Bookstore. AWS A2.4:2020 STANDARD SYMBOLS FOR WELDING, BRAZING, AND NONDESTRUCTIVE EXAMINATION](http://awsbookstore.com)

# Questions?