

## DISCONTINUITIES IN WELDED JOINTS, CAST, FORGED AND MILLED PARTS

### Terminology

This Standard replaces and cancels its previous revision.

The CONTEC - Authoring Subcommittee provides guidance on the interpretation of this Standard when questions arise regarding its contents. The Department of PETROBRAS that uses this Standard is responsible for adopting and applying the clauses thereof.

**Technical Requirement:** a provision established as the most adequate and which shall be used strictly in accordance with this Standard. If a decision is taken not to follow the requirement ("non-conformity" to this Standard) it shall be based on well-founded economic and management reasons, and be approved and registered by the Department of PETROBRAS that uses this Standard. It is characterized by the verb forms "shall," "it is necessary...," "is required to...," "it is required that...," "is to...," "has to...," "only ... is permitted," and other equivalent expressions having an imperative nature.

**Recommended Practice:** a provision that may be adopted under the conditions of this Standard, but which admits (and draws attention to) the possibility of there being a more adequate alternative (not written in this Standard) to the particular application. The alternative adopted shall be approved and registered by the Department of PETROBRAS that uses this Standard. It is characterized by the verbal form "should" and equivalent expressions such as "it is recommended that..." and "ought to..." (verbs of a nonmandatory nature). It is indicated by the expression: **[Recommended Practice]**.

Copies of the registered "non-conformities" to this Standard that may contribute to the improvement thereof shall be submitted to the CONTEC - Authoring Subcommittee.

Proposed revisions to this Standard shall be submitted to the CONTEC - Authoring Subcommittee, indicating the alphanumeric identification and revision of the Standard, the clause(s) to be revised, the proposed text, and technical/economic justification for revision. The proposals are evaluated during the work for alteration of this Standard.

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### Foreword

PETROBRAS Technical Standards are prepared by Working Groups - WG (consisting of specialists from PETROBRAS and its Subsidiaries), are commented by PETROBRAS Units and PETROBRAS Subsidiaries, are approved by the Authoring Subcommittees - SCs (consisting of specialists from the same specialty, representing the various PETROBRAS Units and PETROBRAS Subsidiaries), and ratified by the Executive Nucleus (consisting of representatives of the PETROBRAS Units and PETROBRAS Subsidiaries). A PETROBRAS Technical Standard is subject to revision at any time by its Authoring Subcommittee and shall be reviewed every 5 years to be revalidated, revised or cancelled. PETROBRAS Technical Standards are prepared in accordance with PETROBRAS standard N-1. For complete information about PETROBRAS Technical Standards see PETROBRAS Technical Standards Catalog.

### CONTEC

Comissão de Normalização  
Técnica

### SC - 26

Welding

## **FOREWORD**

This Standard is the English version (issued in SEP/2007) of PETROBRAS standard N-1738 REV. B JUL/2003, which is the Revalidation of PETROBRAS standard N-1738 REV. A JUN/97, the contents thereof not altered. In case of doubt, the Portuguese version, which is the valid document for all intents and purposes, shall be used.

## **1 SCOPE**

1.1 This Standard defines the terms used in the denomination of discontinuities in semi-manufacture or manufactured materials, originated from processes of de manufacture and/or erection, fusion welding, casting, forging and milling.

Nota: Discontinuity is the interruption of the typical structures of a part, regarding the homogeneity of physical, mechanical or metallurgical characteristics. It is not necessarily a fault. The discontinuity shall only be considered as a fault when, due to its nature, dimensions or accumulated effect, it makes the part unacceptable, due to non compliance of the minimum requirements of the applicable technical standard.

1.2 This Standard is applicable to procedures started as from its edition date.

1.3 This Standard contains Technical Requirements and Recommended Practices.

## **2 DEFINITIONS**

For the purposes of this Standard the definitions indicated in items 2.1 to 2.3.4 are adopted.

### **2.1 Discontinuity in Welded Joints**

#### **2.1.1 Arc Strike**

Local fault on the base metal surface resulting from the strike of the electric arc.

#### **2.1.2 Bad Reinforcement Angle**

Excessive angle between the base metal surface plan and the plan tangent to the weld reinforcement, traced from the weld toe (see FIGURE A-1 of ANNEX A).

#### **2.1.3 Elongated Cavity**

Empty space not rounded with the larger dimension parallel to the weld axis, may be localized:

- a) at the weld (see FIGURE A-2 part (a) of ANNEX A);
- b) at the weld root (see FIGURE A-2 part (b) of ANNEX A).

#### **2.1.4 Concavity**

Concavity at the weld root, may be:

- a) root concavity located along the center of the weld bead (see FIGURE A-3 part (a) of ANNEX A);
- b) shrinkage groove located on the sides of the weld bead (see FIGURE A-3 part (b) of ANNEX A).

#### **2.1.5 Excessive Concavity**

Fillet weld with excessively concave face (see FIGURE A-4 of ANNEX A).

#### **2.1.6 Excessive Convexity**

Fillet weld with excessively convex face (see FIGURE A-5 of ANNEX A).

#### **2.1.7 Angular Deformation**

Angular distortion of the welded joint relative to the design configuration (see FIGURE A-6 of ANNEX A), except for but welded joint (see angular misalignment in item 2.1.10).

#### **2.1.8 Incompletely Filled Groove**

Insufficient metal on the weld face (see FIGURE A-7 of ANNEX A).

#### **2.1.9 Linear Misalignment**

But welded joint where the part surfaces, even though parallel, are misaligned, exceeding the design configuration (see FIGURE A-8 of ANNEX A).

#### **2.1.10 Angular Misalignment**

Angular misalignment of but welded joint (see FIGURE A-9 of ANNEX A).

#### **2.1.11 Incomplete Fusion**

Incomplete fusion between the fusion zone and the base metal or between passes of the fusion zone, may be localized:

- a) on the weld interface (see FIGURE A-10 part (a) of ANNEX A);
- b) between passes (see FIGURE A-10 part (b) of ANNEX A);
- c) on the weld root (see FIGURE A-10 part (c) and part (d) of ANNEX A).

#### **2.1.12 Inadequate Penetration**

Insufficient metal at the weld root (see FIGURE A-11 of ANNEX A).

### **2.1.13 Fissure**

See preferred term crack (see items 2.1.34 to 2.1.44).

### **2.1.14 Slag Inclusion**

Non metallic material retained in the fusion zone, may be:

- a) aligned (see FIGURE A-12 part (a) and part (b) of ANNEX A);
- b) isolated (FIGURE A-12 part (c) of ANNEX A);
- c) grouped (FIGURE A-12 part (d) of ANNEX A).

### **2.1.15 Metallic Inclusion**

Foreign metal retained in the fusion zone.

### **2.1.16 Micro-Crack**

Crack with microscopic dimensions.

### **2.1.17 Undercut**

Depression in the shape of a cut on the base metal following the weld toe (see FIGURE A-13 of ANNEX A).

### **2.1.18 Root Undercut**

Undercut localized on the weld root edge (see FIGURE A-14 of ANNEX A).

### **2.1.19 Excessive Penetration**

Excessive metal of the fusion zone on the weld root (see FIGURE A-15 of ANNEX A).

### **2.1.20 Burn Thru**

Localized weld burn through (see FIGURE A-16 part (a) of ANNEX A) or excessive penetration (see FIGURE A-16 part (b) of ANNEX A) resulting from fusion bath burn through during welding.

### **2.1.21 Gas Pore**

Round, isolated empty space inside the weld.

### **2.1.22 Superficial Gas Pore**

Gas pore emerging to weld surface.

### **2.1.23 Porosity**

Set of gas pores with uniform distribution, however not aligned (see FIGURE A-17 of ANNEX A).

### **2.1.24 Clustered Porosity**

Set of clustered gas pores (see FIGURE A-18 of ANNEX A).

### **2.1.25 Linear Porosity**

Set of gas pores arranged in line, in a direction parallel to the longitudinal weld axis (see FIGURE A-19 of ANNEX A).

### **2.1.26 Worm Hole**

Set of elongated or fishbone format gas pores located in the fusion zone (see FIGURE A-20 of ANNEX A).

### **2.1.27 Cracking**

See preferred term: crack (see items 2.1.34 to 2.1.44).

### **2.1.28 Crater Pipe**

Metal fault resulting from the contraction of the fusion zone, localized on the weld bead crater (see FIGURE A-21 of ANNEX A).

### **2.1.29 Interdendritic Shrinkage**

Elongated empty space located between dendrites of the fusion zone.

### **2.1.30 Excessive Reinforcement**

Excess of metal in fusion zone, localized on the weld face (see FIGURE A-22 of ANNEX A).

### **2.1.31 Spatter**

Filler metal globules transferred during welding and adhered to the surface of base metal or already solidified fusion zone.

### **2.1.32 Overlap**

Metal excess on the fusion zone overlapped to the base metal on the weld toe, not cast to the base metal (see FIGURE A-23 of ANNEX A).

### **2.1.33 Asymmetric Fillet Weld**

Fillet weld, which legs are significantly unequal not complying with the design configuration (see FIGURE A-24 of ANNEX A).

### **2.1.34 Crack**

Two dimensional discontinuity caused by local rupture of the material.

### **2.1.35 Crater Crack**

Crack locates in weld beam crater, it may be:

- a) longitudinal (see FIGURE A-25 part (a) of ANNEX A);
- b) transversal (see FIGURE A-25 part (b) of ANNEX A);
- c) star shaped (see FIGURE A-25 part (c) of ANNEX A).

### **2.1.36 Star Crack**

Radiating crack smaller than the width of a pass of the considered weld (see radiating crack in item 2.1.38).

### **2.1.37 Lamellar Tearing**

Crack in the shape of steps, located in plans parallel to the milling direction, located on the base metal, close to the fusion zone (see FIGURE A-26 of ANNEX A).

### **2.1.38 Radiating Crack**

Set of cracks starting from the same point, may be located on:

- a) fusion zone (see FIGURE A-27 part (a) of ANNEX A);
- b) heat affected zone (see FIGURE A-27 part (b) of ANNEX A);
- c) base metal (see FIGURE A-27 part (c) of ANNEX A).

### **2.1.39 Longitudinal Crack**

Crack with direction approximately parallel to the longitudinal axis of the weld bead, may be located on:

- a) fusion zone (see FIGURE A-28 part (a) of ANNEX A);
- b) weld interface (see FIGURE A-28 part (b) of ANNEX A);
- c) heat affected zone (see FIGURE A-28 part (c) of ANNEX A);
- d) base metal (see FIGURE A-28 part (d) of ANNEX A).

### **2.1.40 Toe Crack**

Crack starting on the weld toe, generally located on the heat affected zone (see FIGURE A-29 of ANNEX A).

#### **2.1.41 Root Crack**

Crack starting on the weld root, may be located on:

- a) fusion zone (see FIGURE A-30 part (a) of Annex A);
- b) heat affected zone (see FIGURE A-30 part (b) of Annex A).

#### **2.1.42 Branching Crack**

Set of cracks starting from one crack, may be located on:

- a) fusion zone (see FIGURE A-31 part (a) of ANNEX A);
- b) heat affected zone (see FIGURE A-31 part (b) of ANNEX A);
- c) base metal (see FIGURE A-31 part (c) of ANNEX A).

#### **2.1.43 Underbead Crack**

Crack located on the heat affected zone not extending to the surface of the part (see FIGURE A-32 of ANNEX A).

#### **2.1.44 Transverse Crack**

Crack with direction approximately perpendicular to the longitudinal axis of the weld bead, may be located on:

- a) fusion zone (see FIGURE A-33 part (a) of ANNEX A);
- b) heat affected zone (see FIGURE A-33 part (b) of ANNEX A);
- c) base metal (see FIGURE A-33 part (c) of ANNEX A).

### **2.2 Discontinuities in Castings**

#### **2.2.1 Chaplet**

Discontinuity due to incomplete fusion or the cooling supports or taps.

#### **2.2.2 Shrinking**

See preferred term shrinkage cavity in item 2.2.14.

#### **2.2.3 Scab**

Surface protuberance consisting of sand inclusion covered with a thin layer of porous metal.

#### **2.2.4 Shift**

Discontinuity due to shifting of the contact faces of the molding boxes.

### **2.2.5 Misrun**

Insufficient cast metal on the part.

### **2.2.6 Cold Shut**

Globules partially incorporated to the part surface, caused by liquid metal spatter on the mold walls.

### **2.2.7 Inclusion**

Retention of tap or cooler bits inside the part.

### **2.2.8 Sand Inclusion**

Sand loosened into the mold and retained in the cast metal.

### **2.2.9 Running Interruption**

See preferred term: shut metal in item 2.2.10.

### **2.2.10 Shut Metal**

Discontinuity due to the meeting of 2 runs of cast metal that did not melt.

### **2.2.11 Porosity**

Set of gas pores caused by retention of gases during solidification.

### **2.2.12 Crush**

Discontinuity due to crushing inside the mold.

### **2.2.13 Rat Tail**

Depression on the part surface caused by undulations or faults on the mold surface.

### **2.2.14 Shrinkage Cavity**

Empty space resulting from solidification contraction.

### **2.2.15 Segregation**

Localized concentration of alloy elements or impurities.



### **2.2.16 Hot Tear**

Two dimensional discontinuity resulting from local rupture of the material, caused by shrinkage stresses, may occur during or after solidification.

### **2.2.17 Veining**

Discontinuity on the surface of the part, with the aspect of a wrinkle, caused by movement or crack of the sand mold.

## **2.3 Discontinuities in Forgings and/or Millings**

### **2.3.1 Lap**

Discontinuity located in the surface of the part, resulting from incomplete melting during milling or forging.

### **2.3.2 Lamination**

Two dimensional discontinuity parallel to the plate surface, due to porosity or shrinkage cavity of the slab that did not melt during milling.

### **2.3.3 Seam**

Superficial aligned discontinuity due to inclusion or porosity that did not melt during milling.

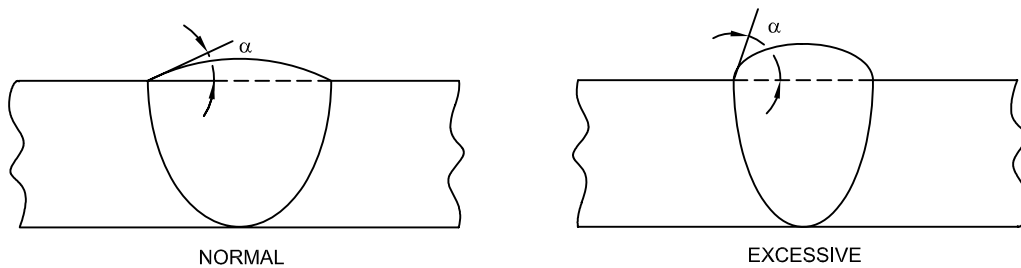
### **2.3.4 Segregation**

Localized concentration of alloy elements or impurities.

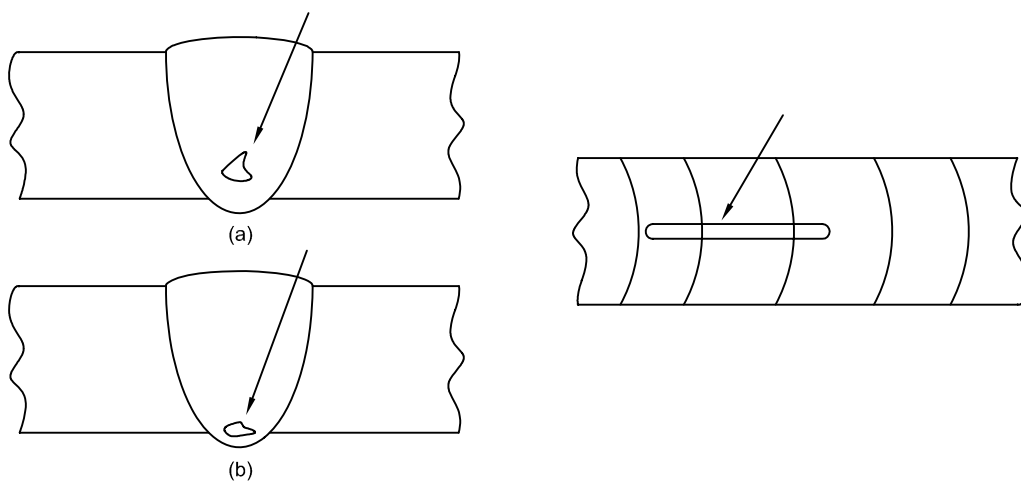
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**/ANNEX A**

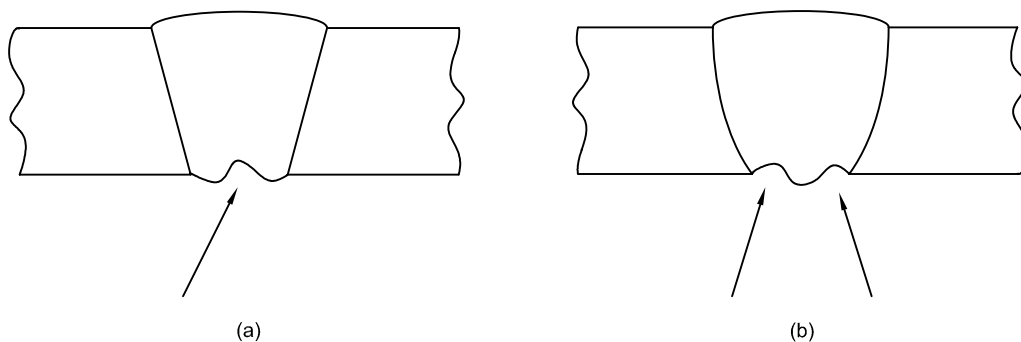
**ANNEX A - FIGURES**



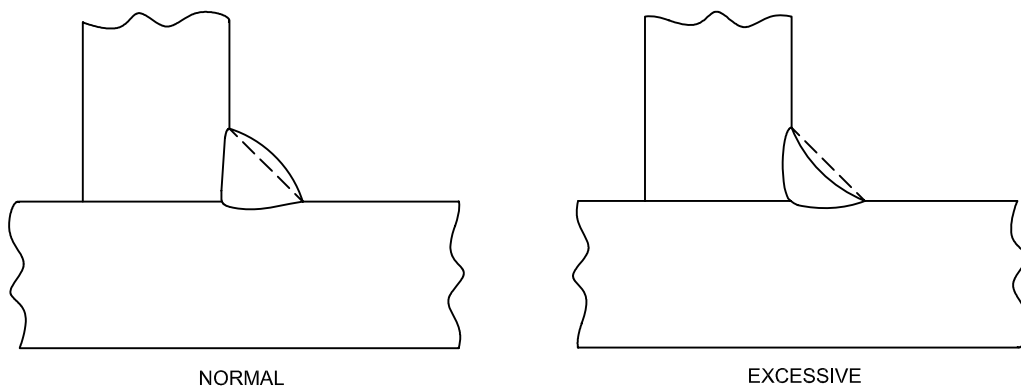
**FIGURE A-1 - BAD REINFORCEMENT ANGLE**



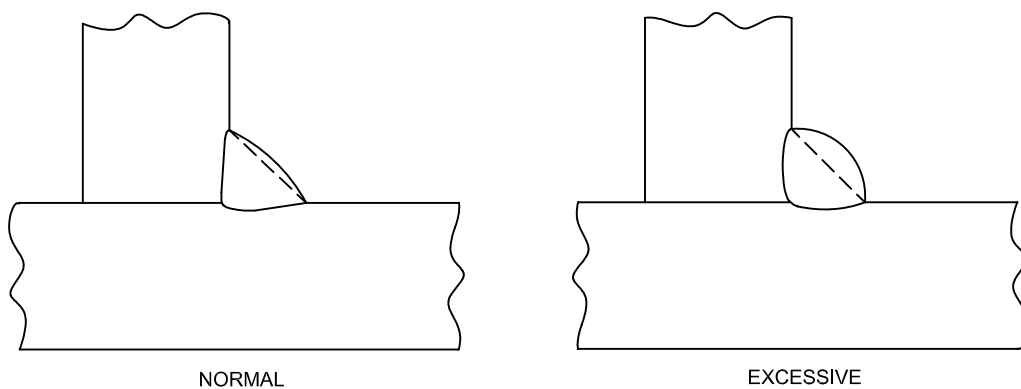
**FIGURE A-2 - ELONGATED CAVITY**



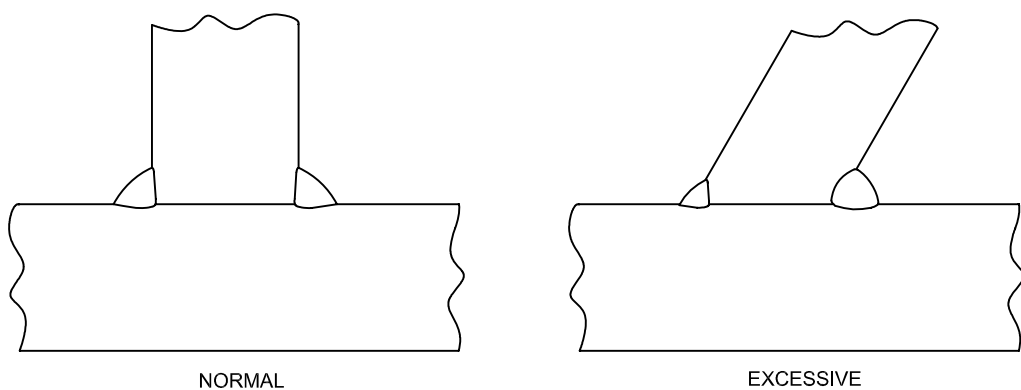
**FIGURE A-3 - CONCAVITY**



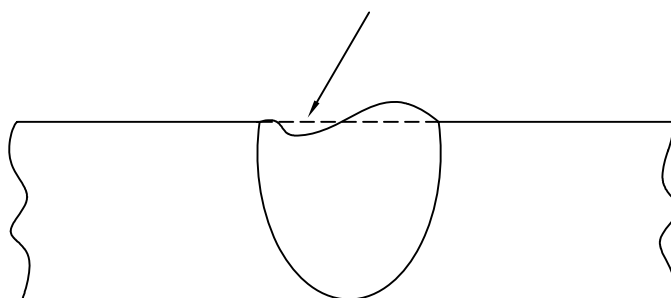
**FIGURE A-4 - EXCESSIVE CONCAVITY**



**FIGURE A-5 - EXCESSIVE CONVEXITY**



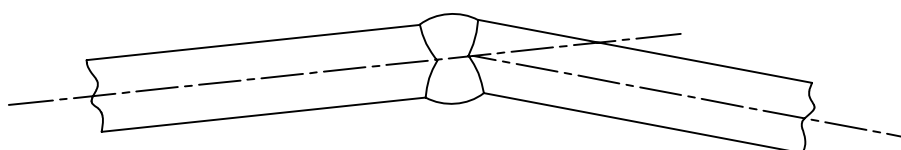
**FIGURE A-6 - ANGULAR MISALIGNMENT**



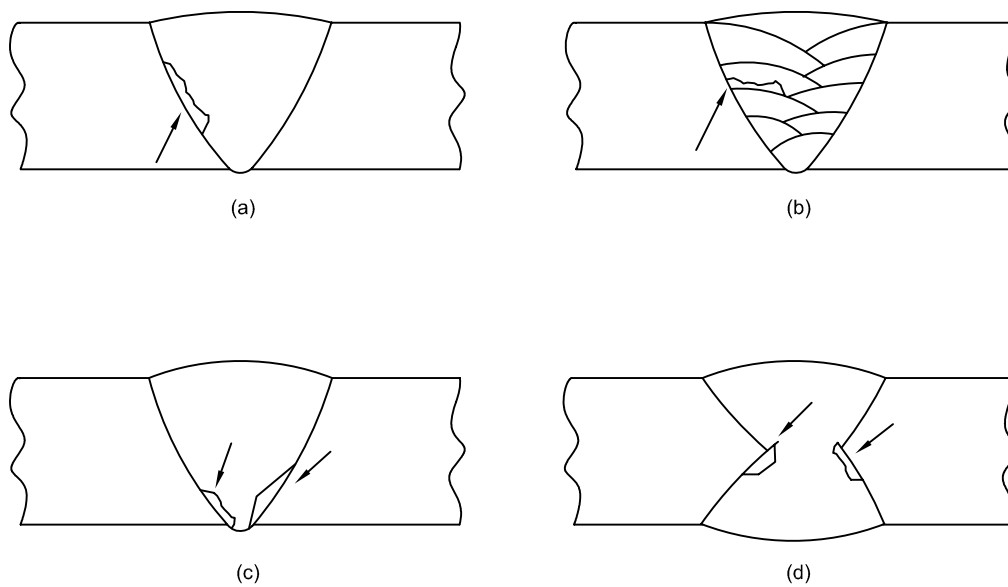
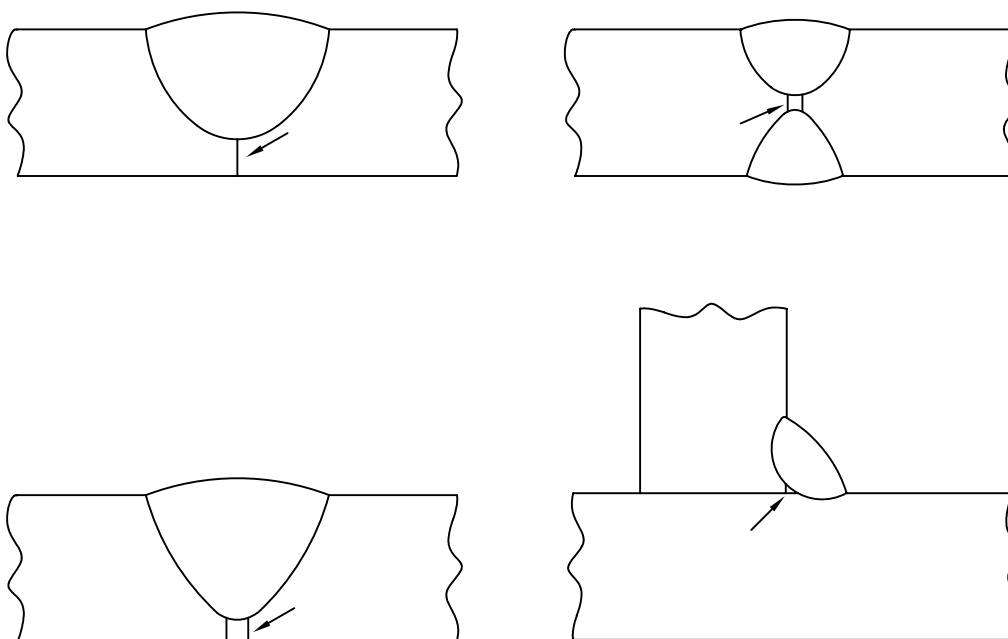
**FIGURE A-7 - INCOMPLETELY FILLED GROOVE**

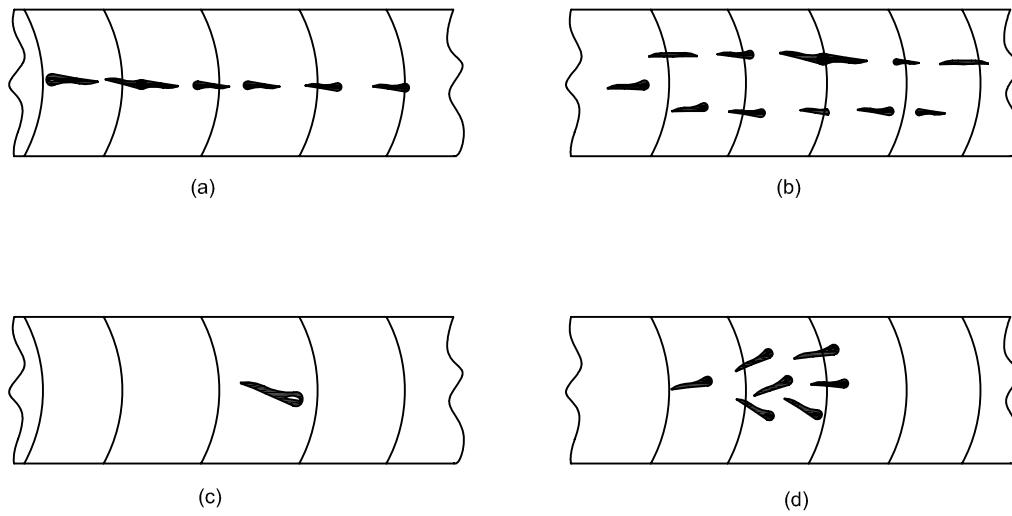


**FIGURE A-8 - LINEAR MISALIGNMENT**

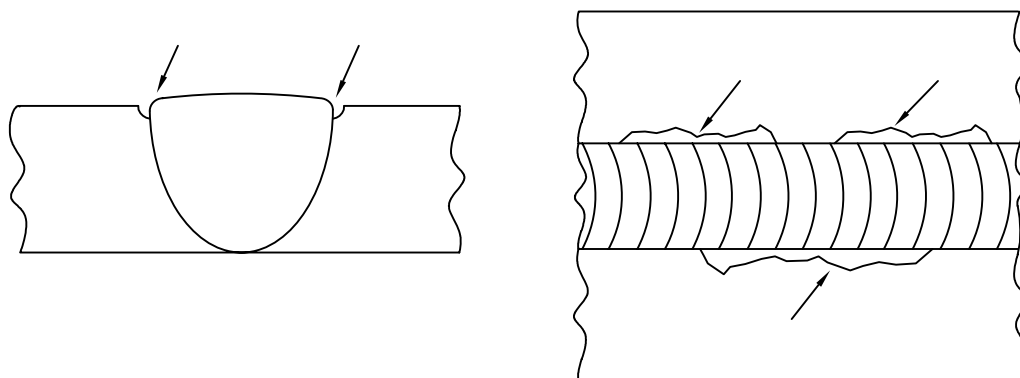


**FIGURE A-9 - ANGULAR MISALIGNMENT**

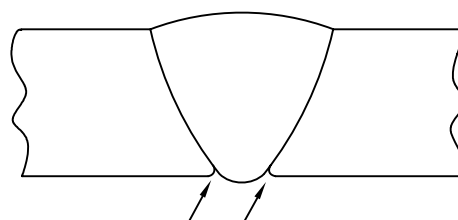
**FIGURE A-10 - INCOMPLETE FUSION****FIGURE A-11 - INADEQUATE PENETRATION**



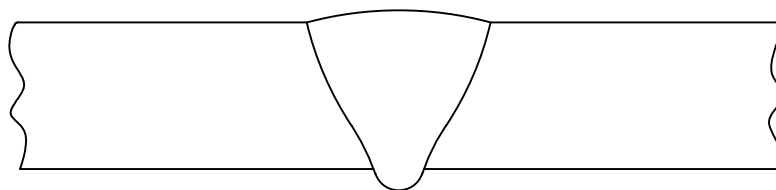
**FIGURE A-12 - SLAG INCLUSION**



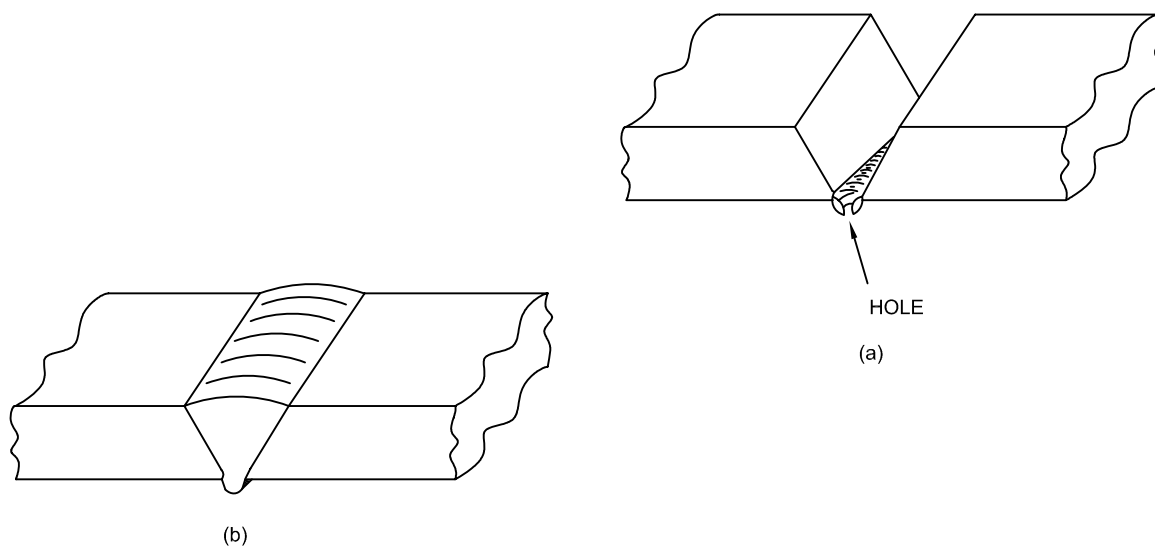
**FIGURE A-13 - UNDERCUT**



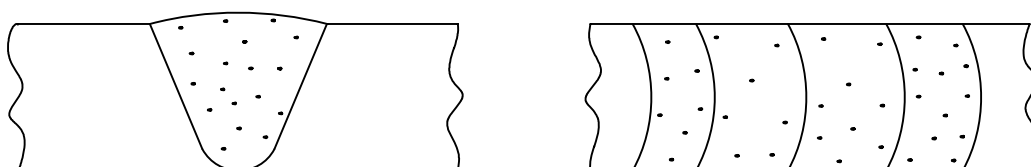
**FIGURE A-14 - ROOT UNDERCUT**



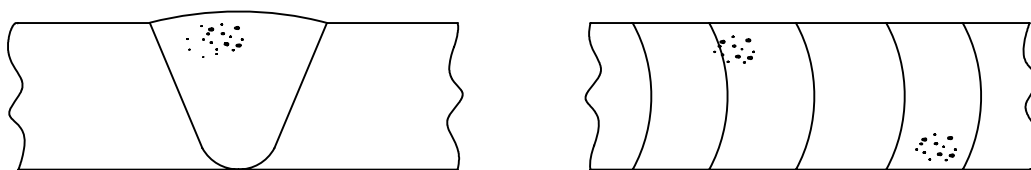
**FIGURE A-15 - EXCESSIVE PENETRATION**



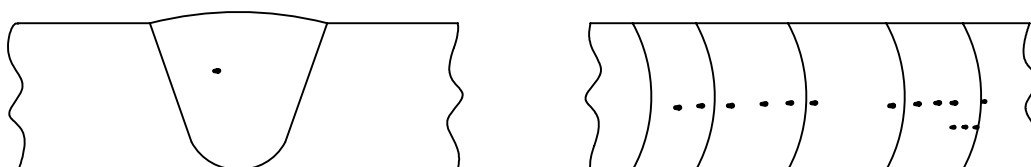
**FIGURE A-16 - BURN THRU**



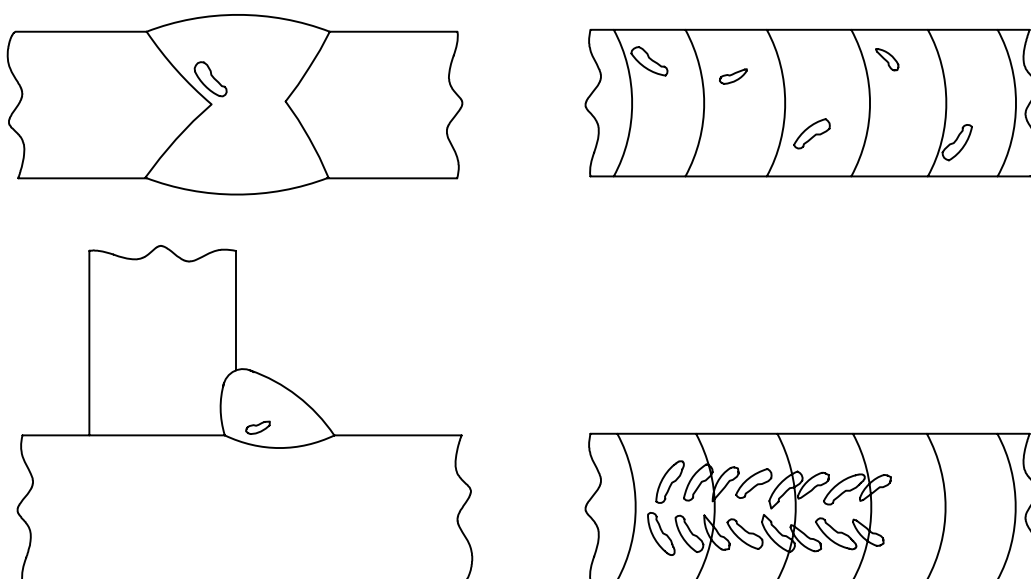
**FIGURE A-17 - POROSITY**



**FIGURE A-18 - CLUSTERED POROSITY**

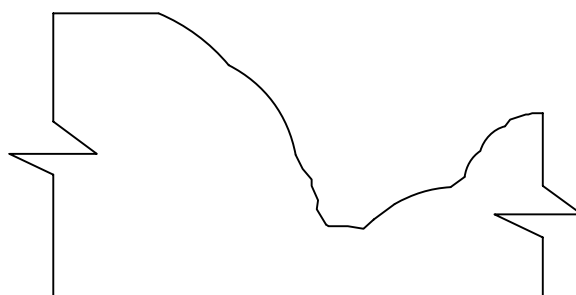


**FIGURE A-19 - LINEAR POROSITY**

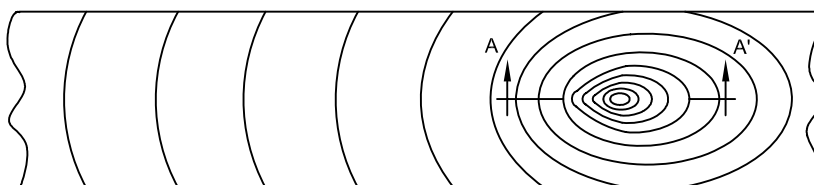


**FIGURE A-20 - WORM HOLE**

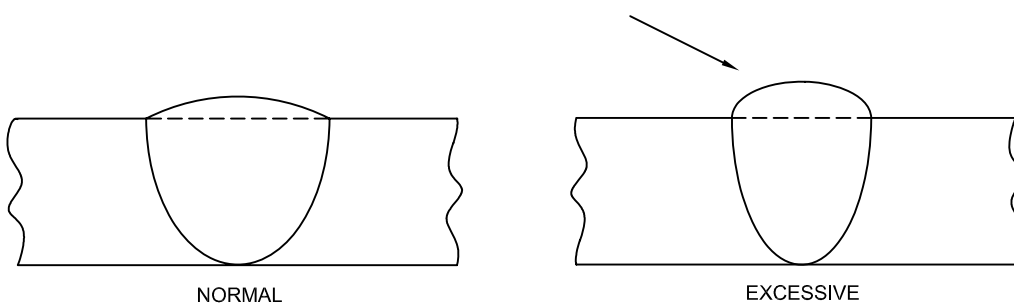




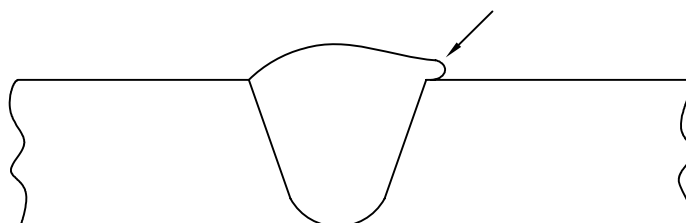
A : A'



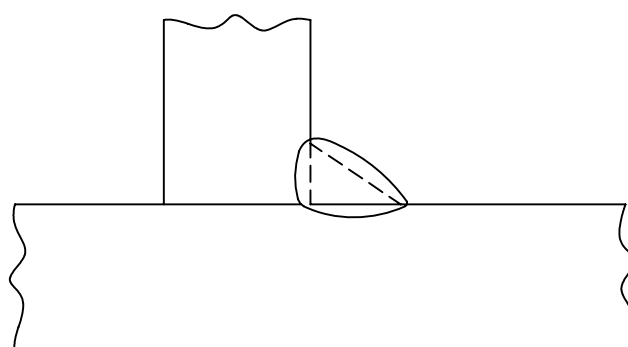
**FIGURE A-21 - CRATER PIPE**



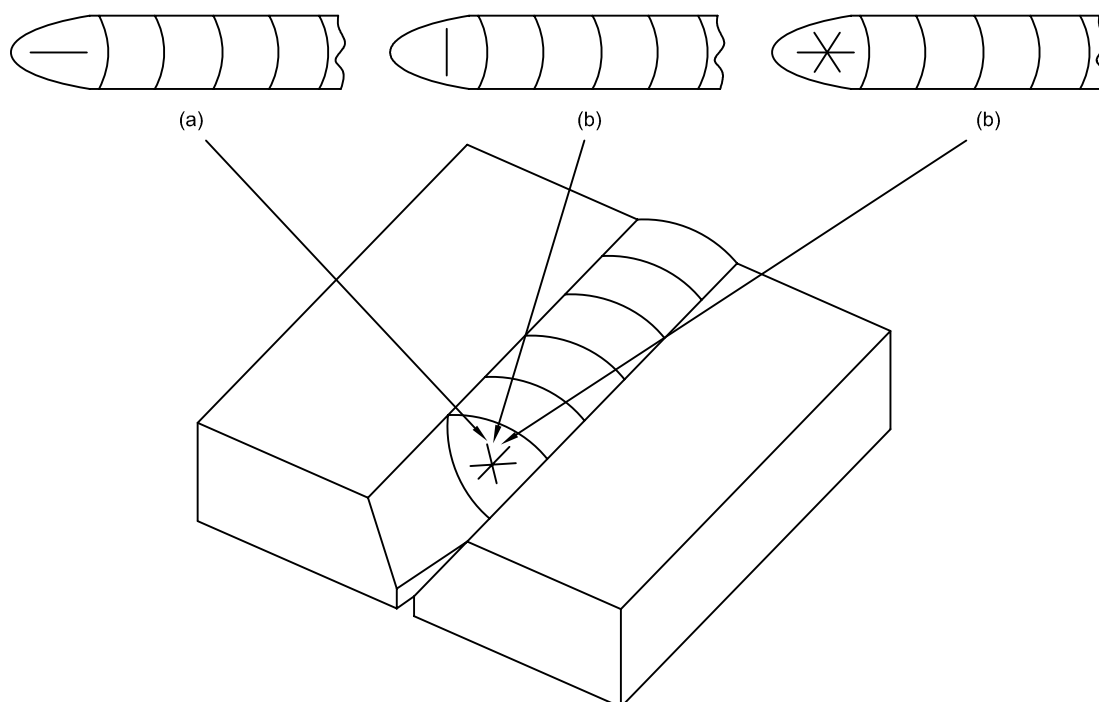
**FIGURE A-22 - EXCESSIVE REINFORCEMENT**



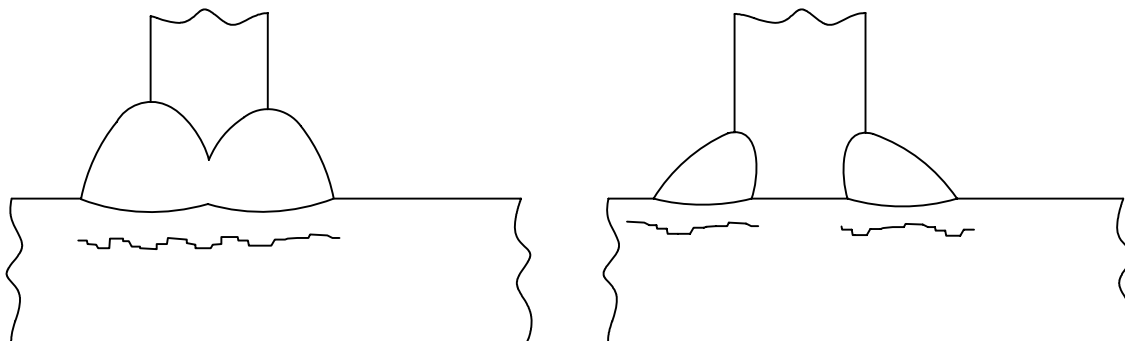
**FIGURE A-23 - OVERLAP**



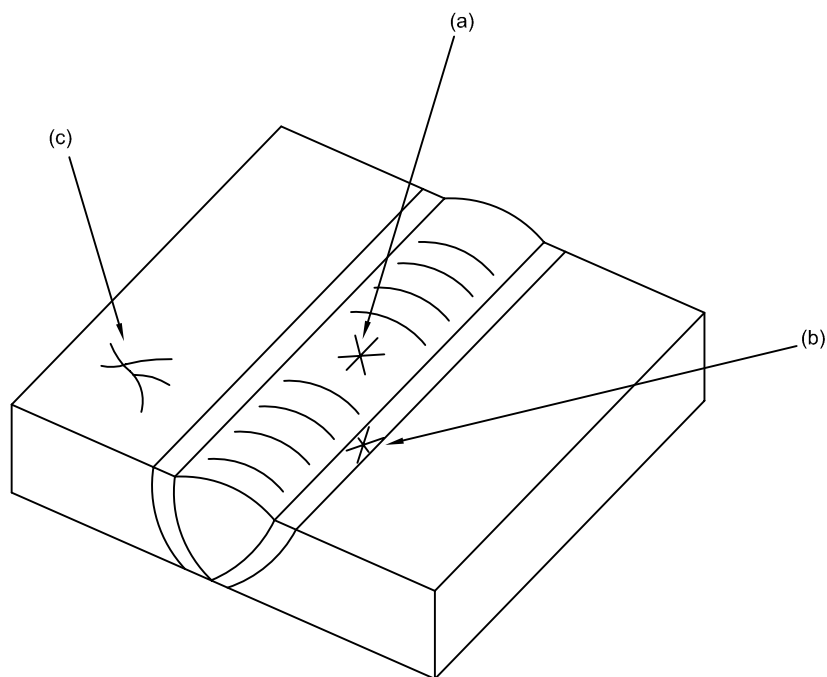
**FIGURE A-24 - ASYMMETRIC FILLET WELD**



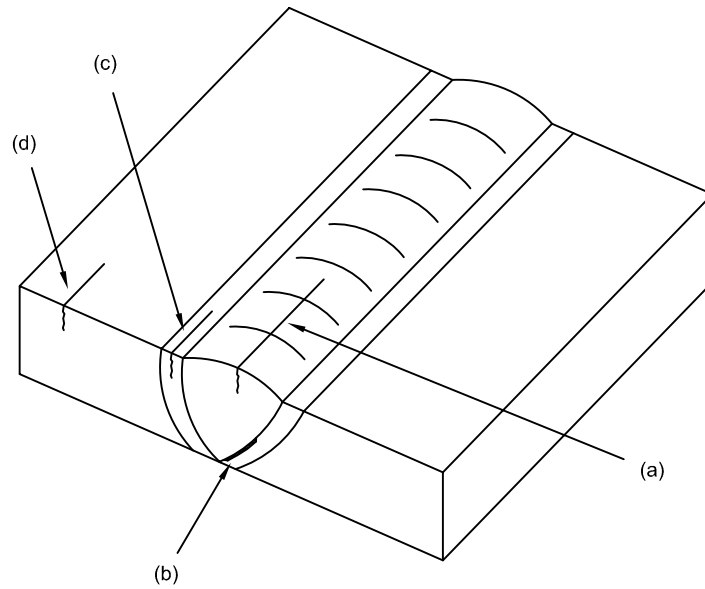
**FIGURE A-25 - CRATER CRACK**



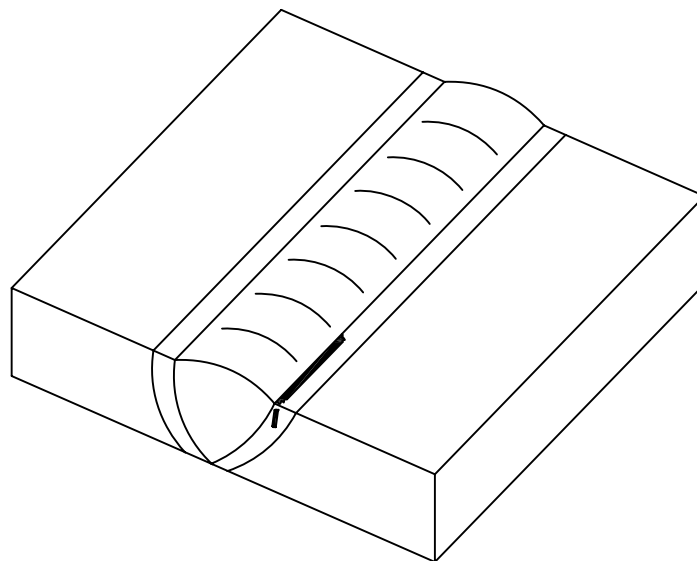
**FIGURE A-26 - LAMELLAR TEARING**



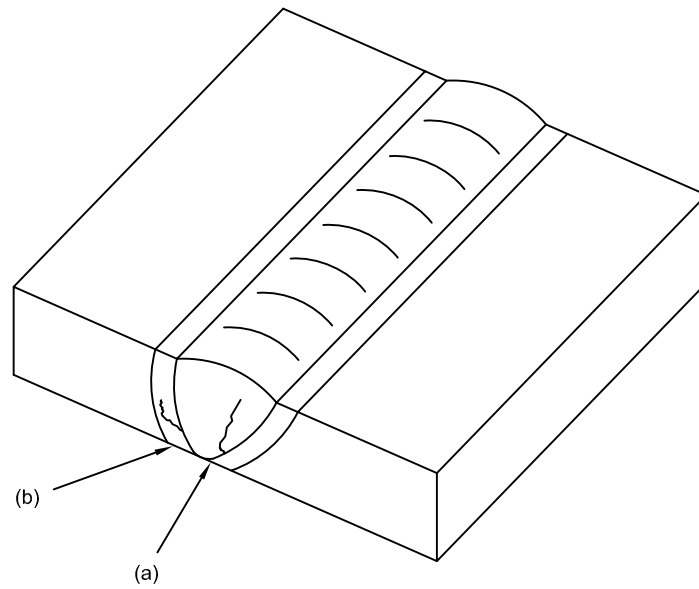
**FIGURA A-27 - RADIATING CRACK**



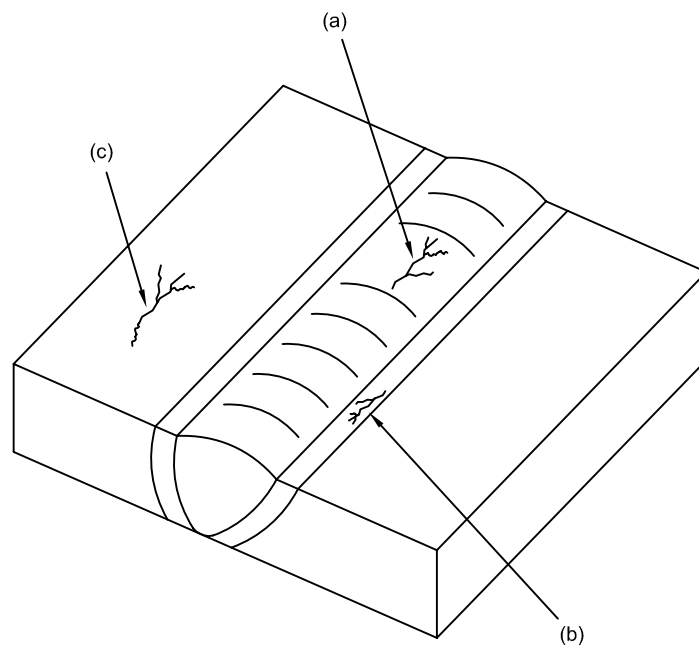
**FIGURE A-28 - LONGITUDINAL CRACK**



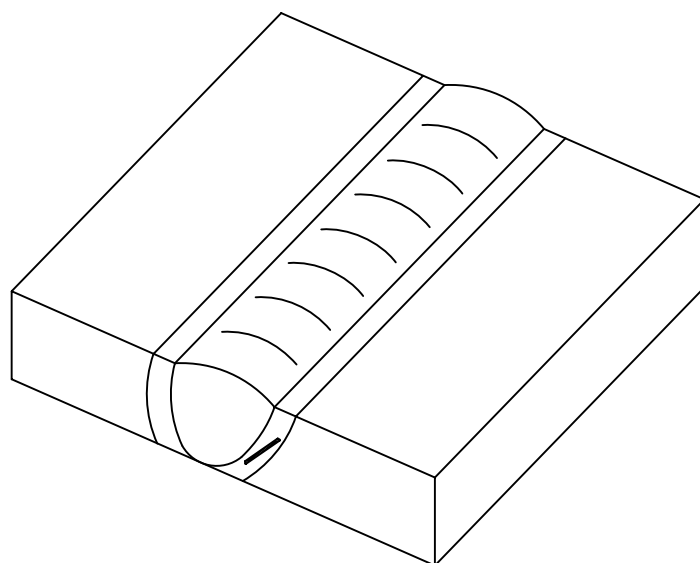
**FIGURE A-29 - TOE CRACK**



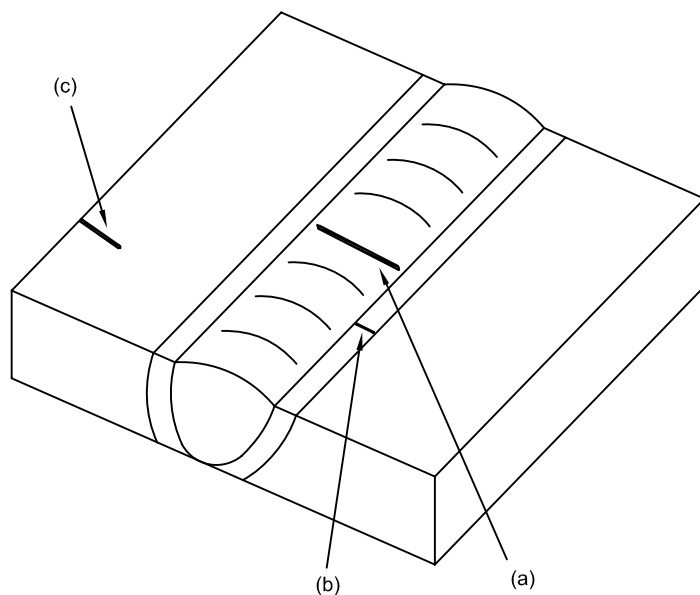
**FIGURE A-30 - ROOT CRACK**



**FIGURE A-31 - BRANCHING CRACK**



**FIGURE A-32 - UNDERBEAD CRACK**



**FIGURE A-33 - TRANSVERSE CRACK**

**ANNEX B - GLOSSARY OF DISCONTINUITIES****B-1 PORTUGUESE-ENGLISH GLOSSARY**

Abertura de Arco	- arc strike.
Ângulo Excessivo de Reforço	- bad reinforcement angle.
Cavidade Alongada	- elongated cavity.
Cavidade Alongada na Raiz	- hollow bead.
Chapelim (fundição)	- chaplet.
Chupagem (fundição)	- shrinkage cavity.
Concavidade	- concavity.
Concavidade Central	- root concavity.
Concavidade Lateral	- shrinkage groove.
Concavidade Excessiva	- excessive concavity.
Convexidade Excessiva	- excessive convexity.
Crosta (fundição)	- scab.
Deformação Angular	- angular misalignment.
Deposição Insuficiente	- incompletely filled groove.
Desalinhamento	- linear misalignment, high-low.
Desencontro (fundição)	- shift.
Dobra	- lap.
Dupla Laminação	- lamination.
Embicamento	- angular misalignment.
Enchimento Incompleto	- misrun.
Falta de Fusão	- lack of fusion, incomplete fusion.
Falta de Penetração	- lack of penetration, inadequate penetration
Fissura	- fissure.
Gota Fria (fundição)	- cold shut.
Inclusão (fundição)	- insert.
Inclusão de Areia (fundição)	- sand inclusion.
Inclusão de Escória	- slag inclusion.
Inclusão Metálica	- metallic inclusion.
Interrupção de Vazamento (fundição)	- shut metal.
Lasca	- seam.
Metal Frio (fundição)	- shut metal.
Micro Trinca	- micro crack.
Mordedura	- undercut.
Penetração Excessiva	- excessive penetration.
Perfuração	- burn thru, excessive melt thru.
Poros	- gas pore.
Porosidade	- gas pocket, porosity, blow hole.
Porosidade (fundição)	- porosity.
Porosidade Agrupada	- clustered porosity.
Porosidade Alinhada	- linear porosity.
Porosidade Vermiforme	- worm-hole.
Queda de Bolo (fundição)	- crush.
Rabo de Rato (fundição)	- rat tail.
Rechupe (fundição)	- shrinkage cavity.
Rechupe de Cratera	- crater pipe.
Rechupe Interdendrítico	- interdendritic shrinkage.
Reforço Excessivo	- excessive reinforcement.
Respingos	- spatter.
Segregação (fundição, forjamento, laminação)	- segregation.
Sobreposição	- overlap.

Solda em Ângulo Assimétrica  
 Trinca  
 Trinca de Cratera  
 Trinca de Contração (fundição)  
 Trinca em Estrela  
 Trinca Interlamelar  
 Trinca Irradiante  
 Trinca Longitudinal  
 Trinca na Margem  
 Trinca na Raiz  
 Trinca Ramificada  
 Trinca sob Cordão  
 Trinca Transversal  
 Veio (fundição)

- assymetrical fillet weld.  
 - crack.  
 - crater crack.  
 - hot tear.  
 - star crack.  
 - lamellar tearing.  
 - radiating crack.  
 - longitudinal crack.  
 - toe crack.  
 - root crack.  
 - branching crack.  
 - underbead crack.  
 - transverse crack.  
 - veining, fin.

## **B-2 ENGLISH-PORTUGUESE GLOSSARY**

Angular Misalignment  
 Arc Strike  
 Assymetrical Filler Weld  
 Bad Reinforcement Angle  
 Blow Hole  
 Branching Crack  
 Burn Thru  
 Chaplet  
 Clustered Porosity  
 Cold Shut  
 Concavity  
 Crack  
 Crater Crack  
 Crater Pipe  
 Crush  
 Elongated Cavity  
 Excessive Concavity  
 Excessive Convexity  
 Excessive Melt Thru  
 Excessive Penetration  
 Excessive Reinforcement  
 Fin  
 Fissure  
 Gas Pocket  
 Gas Pore  
 High-Low  
 Hollow Bead  
 Hot Tear  
 Inadequate Penetration  
 Incomplete Fusion  
 Incompletely Filled Groove  
 Insert  
 Interdendritic Shrinkage  
 Lack of Fusion  
 Lack of Penetration  
 Lamellar Tearing  
 Lamination  
 Lap

- embicamento, deformação angular.  
 - abertura de arco.  
 - solda em ângulo assimétrica.  
 - ângulo excessivo de reforço.  
 - porosidade.  
 - trinca ramificada.  
 - perfuração.  
 - chapelim (fundição).  
 - porosidade agrupada.  
 - gota fria (fundição).  
 - concavidade.  
 - trinca.  
 - trinca de cratera.  
 - rechupe de cratera.  
 - queda de bolo (fundição).  
 - cavidade alongada.  
 - concavidade excessiva.  
 - convexidade excessiva.  
 - perfuração.  
 - penetração excessiva.  
 - reforço excessivo.  
 - veio (fundição).  
 - fissura.  
 - porosidade.  
 - poro.  
 - desalinhamento.  
 - cavidade alongada na raiz.  
 - trinca de contração (fundição).  
 - falta de penetração.  
 - falta de fusão.  
 - deposição insuficiente.  
 - inclusão (fundição).  
 - rechupe interdendrítico.  
 - falta de fusão.  
 - falta de penetração.  
 - trinca interlamelar.  
 - dupla laminação (laminação).  
 - dobra (laminação, forjamento).



Linear Misalignment	- desalinhamento.
Linear Porosity	- porosidade alinhada.
Longitudinal Crack	- trinca longitudinal.
Metallic Inclusion	- inclusão metálica.
Micro Crack	- micro-trinca.
Misrun	- enchimento incompleto (fundição).
Overlap	- sobreposição.
Porosity	- porosidade.
Radiating Crack	- trinca irradiante.
Rat Tail	- rabo de rato (fundição).
Root Concavity	- concavidade central.
Root Crack	- trinca na raiz.
Sand Inclusion	- inclusão de areia (fundição).
Scab	- crosta (fundição).
Seam	- lasca (forjamento, laminação).
Segregation	- segregação (fundição, forjamento, laminação).
Shift	- desencontro (fundição).
Shrinkage Cavity	- rechupe, chupagem (fundição).
Shrinkage Groove	- concavidade lateral.
Shut Metal	- metal frio, interrupção de vazamento (fundição).
Slag Inclusion	- inclusão de escória.
Spatter	- respingos.
Star Crack	- trinca em estrela.
Toe Crack	- trinca na margem.
Transverse Crack	- trinca transversal.
Underbead Crack	- trinca sob cordão.
Undercut	- mordedura.
Veining	- veio (fundição).
Worm Hole	- porosidade vermiforme.

## INDEX OF REVISIONS

**REV. A**

There is no index of revisions.

**REV. B**

[illegible]