

CASTING DEFECTS HANDBOOK: COPPER & COPPER-BASE ALLOYS

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Published by the American Foundry Society, Schaumburg, IL USA

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Reprinted 2012

Printed in the United States of America

ISBN 978-0-87433-365-7

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Introduction

Copper base metals are shape-cast usually either in sand molds or permanent molds. Several types of defects are associated primarily with sand molds and cores, and are related in most instances to improper and/or incomplete molding processes or the breakdown of the mold and/or core during pouring and solidification of the casting. These defects include veins, scabs, buckles, swells, stickers, drops, etc.

Other defects are metallurgical in nature and can occur in either non-metal or metal mold processes. These include pouring defects, inclusions and gas and other microstructural phenomena arising from the specific alloy composition and solidification characteristics (for example 'tin sweat').

Still other defects occur from mishandling—broken castings or cracked castings; and hot tears, which may be caused by irregular casting geometry, metal composition inhomogeneity or inadequate pouring practice.

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CHAPTER 1

Broken or Cracked Castings

Description

These casting defects (and rejects) result from mishandling, mechanical action, or thermal shock, which can apply to both the mold and the casting. These failures can also result from non-homogeneous alloy composition in the liquid state and from impurities, which alter the solidification characteristics. Irregular solidification causes microstructural weakness in the casting.

Causes

1. Mechanical and Equipment

- Poor casting design (lack of fillets)
- Irregular sections
- Improper break off notches on gates and risers
- Flask bars improperly positioned
- Shakeout too hot or rough
- Mechanical cleaning (tumbling) too rough
- Improper stacking
- Dropping the casting
- General carelessness

2. Sand, Core, and Molding Practice

- Poor sand collapsibility
- High hot compressive strength coupled with hot sand deformation
- Over-reinforced cores
- Improper use of chills
- Risers or sprues located too close to a flask bar
- Excessive ramming

3. Gating, Riser and Pouring

- Pouring temperature insufficient to allow proper mold collapsibility, thereby restraining natural thermal contraction of the casting as it solidifies (also relates to hot cracking or hot tears)
- Lack of fillets at gate and/or riser connections leading to hot spots
- Pouring too hot with excessive shrinkage

4. Metallurgical

- Non-homogenous liquid metal ready for pouring
- Impurities, which detract from hot or cold strength during solidification and subsequent metal handling.



Fig. 1-1. Aluminum in red brass is an impurity that results in casting micro-structural weakness prone to cracking.

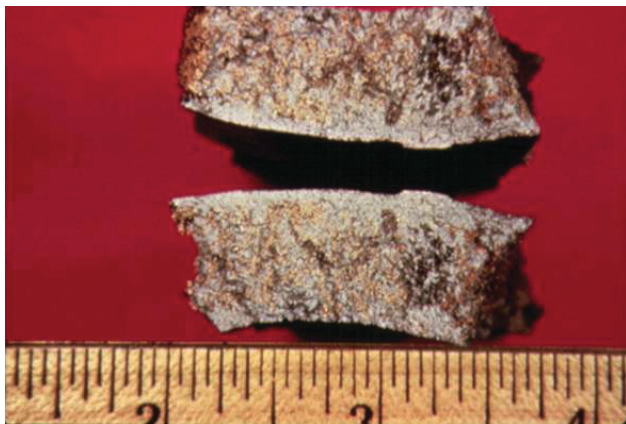


Fig. 1-2. Silicon in red brass is an impurity concentration that results in casting microstructural weakness prone to cracking.



Fig. 1-3. The yellow brass handle, cast in green sand, exhibits unusually large dendritic growth. This is evidence of a melt and/or pour temperature, which is too high, and also of zinc flaring.



Fig. 1-4. The broken core shows low binder content, poor density and age.

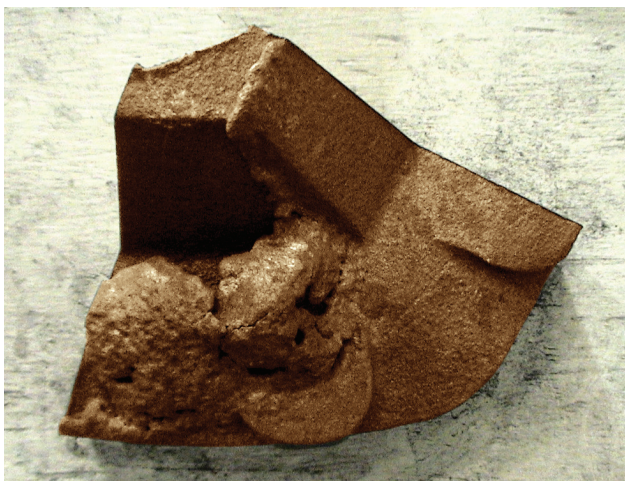


Fig. 1-5. The cracked mold is caused by push up or drop. The drag sand level is not full.

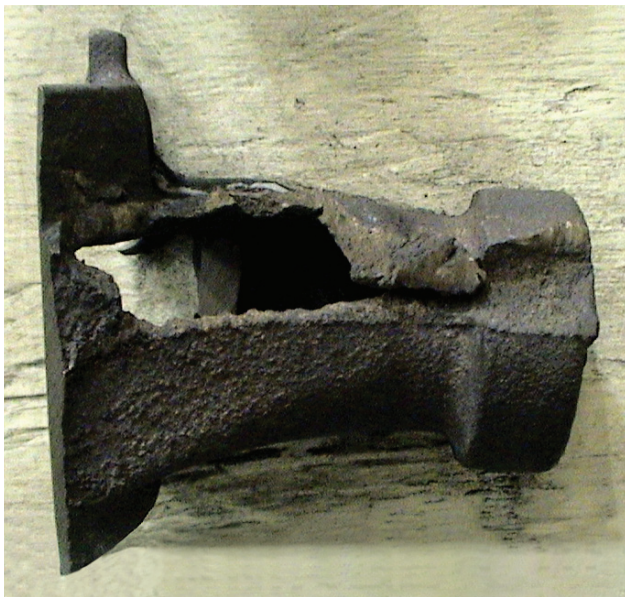


Fig. 1-6. The punch damage in red brass during de-molding is caused by sticker. The die clearance and/or mating is incorrect



Fig. 1-7. Broken mold

CHAPTER 2

Scars, Seams, Plates, and Flow Marks

Description

These are shallow surface defects often, but not always, seen just on larger flat surfaces of a casting. A scar is a minor, shallow mark on the casting where it does not conform to the pattern. A seam is a minor indentation, whereas a plate is a layer of metal slightly raised from the main casting surface. In general, such defects, which arise from pattern equipment and mold making, are exacerbated by inadequate pouring actions. A flow mark is a surface visual defect, encountered in metal molds where there is non-uniform liquid metal flow during filling, and is often associated with a thin oxide film.

Causes

1. Mechanical and Equipment

- Worn pattern equipment
- Abrupt changes in casting section which create turbulent metal flow
- Pattern improperly mounted
- Cope and drag shift causing thin metal sections

2. Sand, Core, and Molding Practice

- Excessive moisture
- Low permeability
- High expansion sand
- Low hot deformation

- Excessive gas forming material
- Plugged vents
- Off size or distorted cores
- Irregular core and/or mold wash surface
- Non-uniform mold and/or core forming and ramming
- Excessive sticking, patching, mold repair

3. Gating, Riser, Pouring

- Interrupted or irregular pouring rate
- Gassy metal
- Pouring temperature too low, allows premature solidification in thin sections
- Lack of tilt in pouring thin flat horizontal sections
- Rough handling—turbulence during pouring

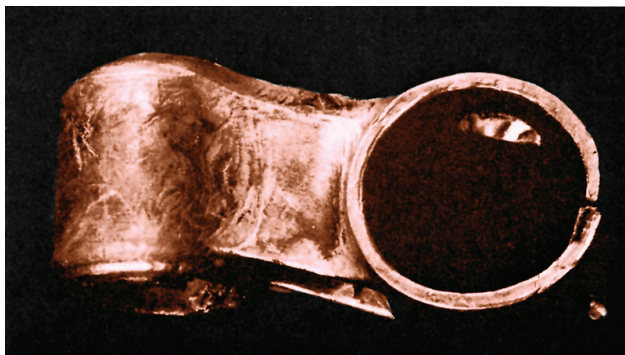


Fig. 2-1. Bicycle bracket in 90-10 cupro-aluminum, cast in permanent mold, shows seams, and oxide skins.



Fig. 2-2. Same casting as in Fig. 2-1 shows flow marks caused by high pouring temperature and turbulent filling of the mold.

CHAPTER 3

Expansion Defects (Rattails, Buckles, Scabs, Veining)

Description

These green sand defects are mainly related to problems with the molding sand and molding practice, and arise during the pouring operation. Expansion defects include rattails, buckles, scabs, and veining. Expansion (and contraction) occurs as the molding sand and cores undergo temperature cycling during the pouring operation. Silica sand undergoes the most dimensional change, although other mold material compositions are also prone. While higher temperature-regime ferrous metal castings suffer more from these expansion defects, copper and copper base alloy castings can also exhibit these defects.

Causes

1. Mechanical/Equipment

- Rough mechanical handling of cores, molds and flasks leading to cracks in molds and cores
- Uneven sections in pattern equipment causing uneven heat distribution in heat processing of molds and cores
- Sharp corners that develop hot spots
- Misaligned equipment

2. Sand, Core Molding

- Poor mulling and mixing
- Improper binder level
- Poor sand distribution
- Sand grain shape too regular (too round)
- Cores and molds too weak due to insufficient molding
- Excessive moisture which cannot escape during drying
- Excess binders
- Core baking temperatures too high
- Improperly reinforced cores-rods, wires or bars
- Cores stored in high humidity conditions

3. Gating, Riser and Pouring

- Gate or riser location too close to core print, causing hot spots leading to mold or core cracking before the metal solidifies and subsequent metal penetration
- Faulty mold coating
- Excessive head pressure
- Pouring temperature too high

• Rattail

A rattail is a rather shallow irregular groove-type of defect appearing usually on horizontal drag surfaces, and often extending from gate locations. Heat from the flowing metal causes steam formation of the moisture in the green sand at the surface. This causes expansion as the steam escapes and creates a protrusion, resulting in a 'negative' or rivulet as the casting surface solidifies.

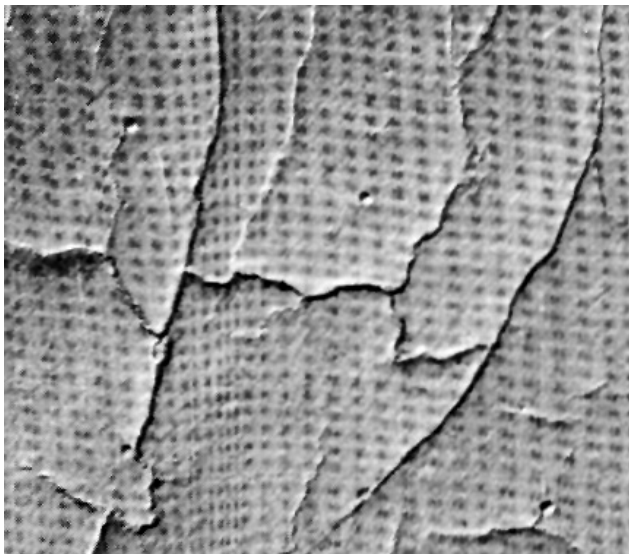


Fig. 3-1. Rattail

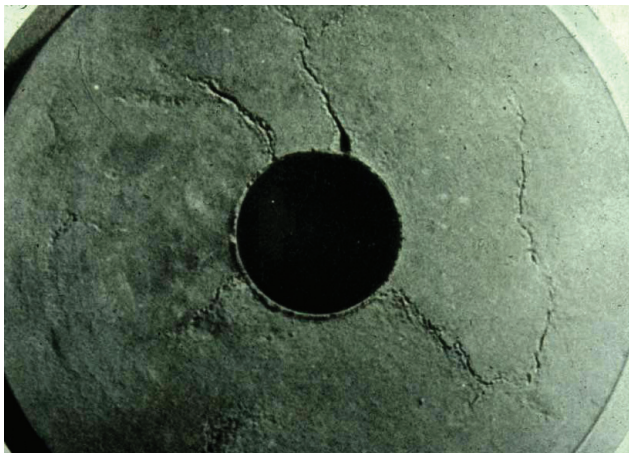


Fig. 3-2. Rattail



Fig. 3-3. Rattail

• Buckle

A buckle is a 'heaving' of the sand during pouring and is a precursor to an expansion defect. This often occurs on both horizontal cope and drag surfaces.

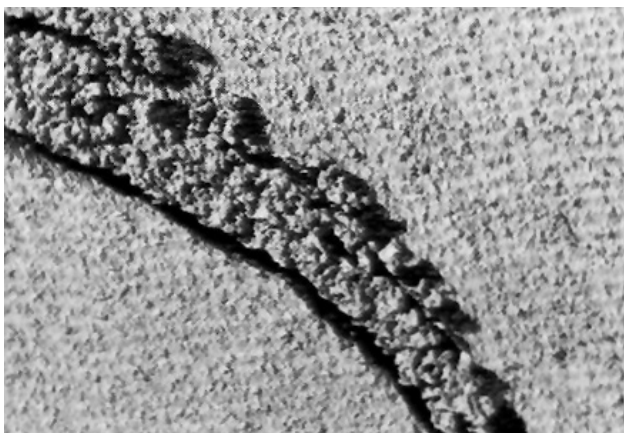


Fig. 3-4. Buckle

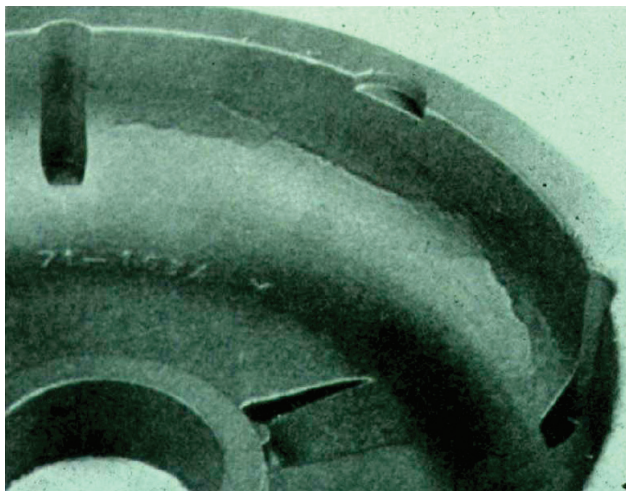


Fig. 3-5. Buckle

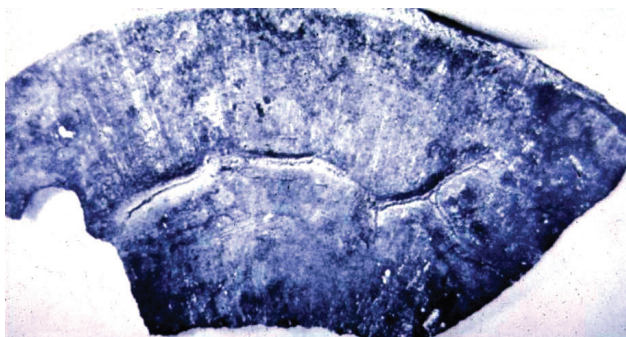


Fig. 3-6. Buckle

- **Scab**

A scab expansion defect occurs as the mold surface undergoes expansion and contraction during pouring and metal solidification. This defect may result from breakdown of the sand or also from erosion of mold and core washes. Scabs are 'positive' metal defects; appear crusty; may be somewhat 'loose' and can often be removed during finishing operations, if not severe.

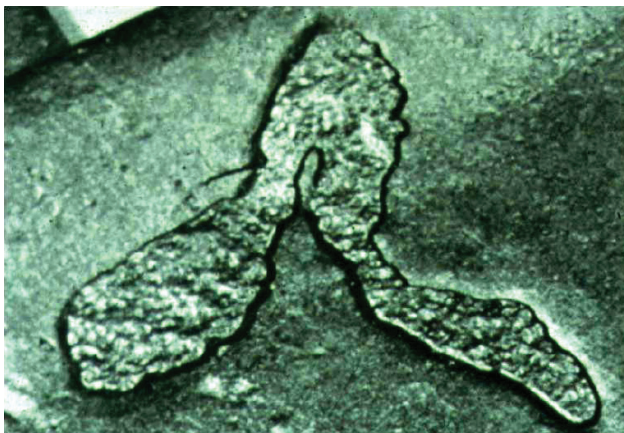


Fig. 3-7.Scab



Fig. 3-8.Scab



Fig. 3-9. Scab



Fig. 3-10. Fillet scab

- **Veining**

Veining, an irregular linear defect, a ridge or projection on the casting surface, is found in the sandcasting process. Invariably there is a separation in the molding media for various reasons, and the metal fluidity is sufficient to penetrate the separation or crack in the mold and/or core material. This allows the defect to appear when the casting surface is examined.

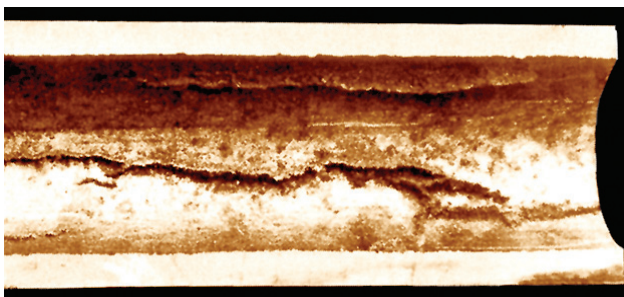


Fig. 3-11. Veining is caused by core cracks in bronze bushing and improper core baking.

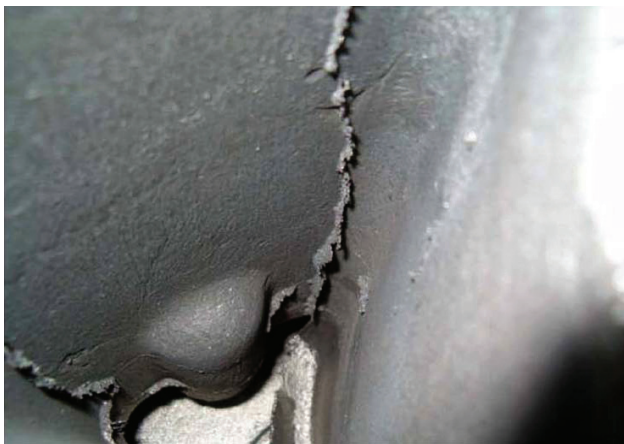


Fig. 3-12. Veining



Fig. 3-13. Severe veining in red brass C83600

5. Flash or Finning

Flash or finning should not be confused with veining. Flash and/or finning occurs as a positive defect, which appears linearly at the mold parting line. This defect is due to inadequate mold closure or mold mismatch. In severe situations, flash or finning becomes gross run-out.

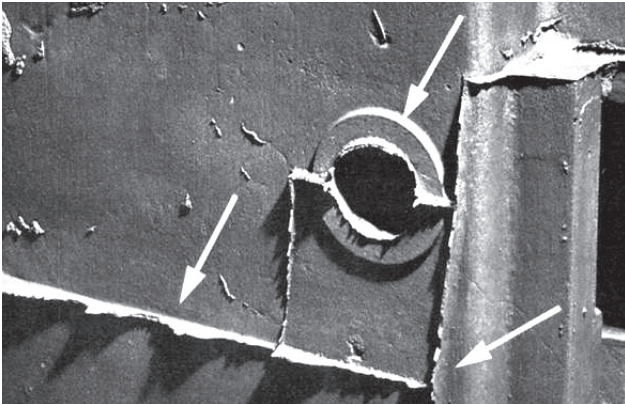


Fig. 3-14. Flash and fins

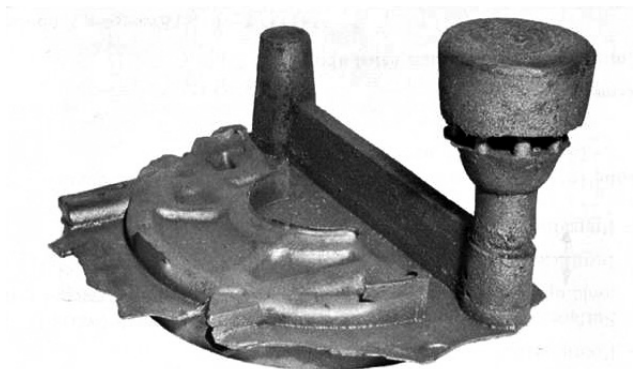


Fig. 3-15. Run-out is due to poor mold mismatch or inadequate closure.

CHAPTER 4

Sand Molding Defects (Crushes, Swells, Sags, Drops, Erosion, Stickers, Cuts and Washes, Poor Surface)

Description

There are several defects which relate strictly to casting processes with sand molding materials. These include crushes, swell, sags, drops, erosion, stickers, cuts and washes and poor surface. Molded cores can create defects due to inadequate or incorrect core production (poor strength, insufficient curing, etc) or poor alignment and placement in registry with the main casting mold cavity.

Causes

Most Sand Molding Defects Arise from One or More of the Following Factors:

- Improper sand grain size distribution
- Inadequate mulling
- Too little or too much binder
- Too little or too much moisture
- Insufficient or excessive molding pressure
- Pattern design which does not permit sufficient material fill or pressure

- **Crushes**

A crush is a non-geometric projection on vertical or oblique surfaces of the casting in the direction in which the mold is closed or in which a core is placed.

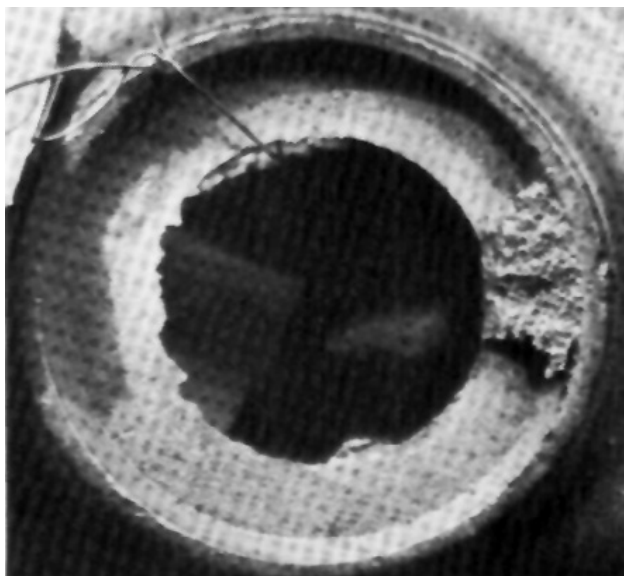


Fig. 4-1. Crush



Fig. 4-2. Core crush from insufficient core strength



Fig. 4-3. Crush can be caused by misaligned cope/drag, mismatched pattern halves, bad pins, and bushings.

- **Swells**

A swell is often a massive 'wavy' irregular projection, which can be found on all surfaces of the problem casting. Swells are caused by excessive liquid metal pressure relative to the strength of the mold.



Fig. 4-4. Swell



Fig. 4-5. Swell is caused by cracked sand mold in red brass (C83600).

• Sags

A sag is an irregular, fin like projection of varying thickness and shape, having a rough and irregular surface, caused by the pressure of the metal as it contacts the mold cavity surface. The metallostatic pressure exceeds the sand strength.

• Drops

A drop is a defect due to the loss of a portion of the sand from the cope or other overhanging section.

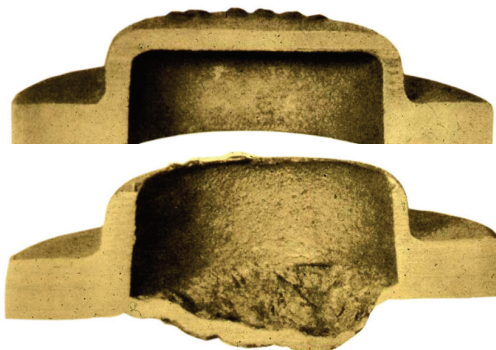


Fig. 4-6. Drop

- **Erosion Scabs**

While similar in appearance to an expansion scab, an erosion scab is usually found in the drag, where sand has been loosened by the metallostatic pressure of flowing metal during pouring.



Fig. 4-7. Erosion scab

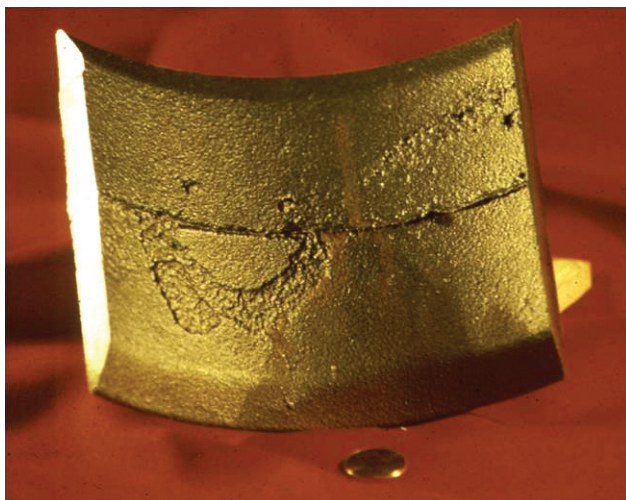


Fig. 4-8. Erosion scab

- **Stickers**

A sticker defect is an irregular massive projection usually found on the cope surface and suggests a detachment of the mold wall. Stickers can be mechanically related—pattern equipment, molding apparatus or inadequate sand molding procedures.

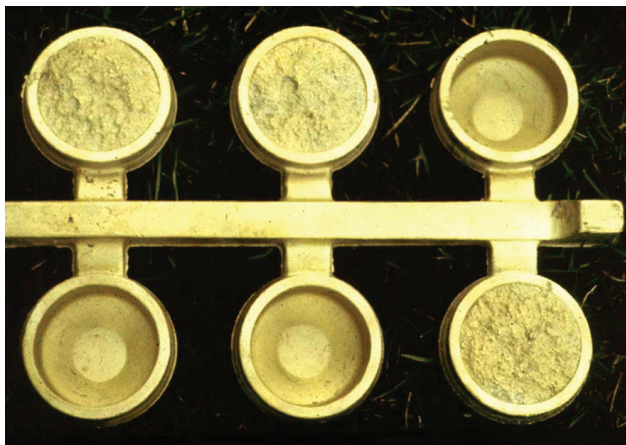


Fig. 4-9. Sticker



Fig. 4-10. Sticker is caused by poor sand molding and pattern problems

- **Cuts and Washes**

Cuts and washes are irregular, rough projections on the surfaces of a casting. They are usually in the vicinity of gates or on the drag surface following a line along the course of metal flow into the mold cavity.

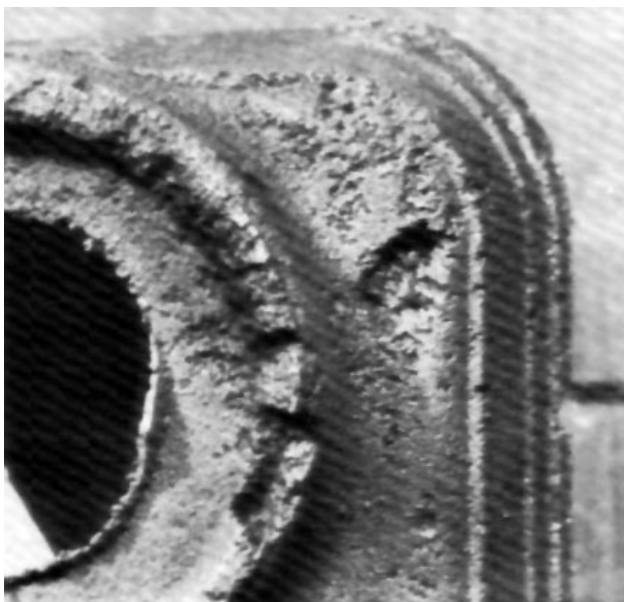


Fig. 4-11. Wash



Fig. 4-12 Wash

- **Poor Surface**

Poor surface is generally the result of grain fineness distribution being too coarse, insufficient green sand strength or erosion of the mold surface during pouring (too turbulent).



Fig. 4-13. Rough surface on red brass is due to wet sand (moisture too high).



Fig. 4-14. Rough surface on red brass is due to too coarse grain fineness distribution.

• Core Problems

Core problems result from improper to incorrect core production (sizing) or inadequate core setting within the mold prior to closing.



Fig. 4-15. Dimensionally incorrect core in red brass results in crush.



Fig. 4-16. Improper core alignment in red brass

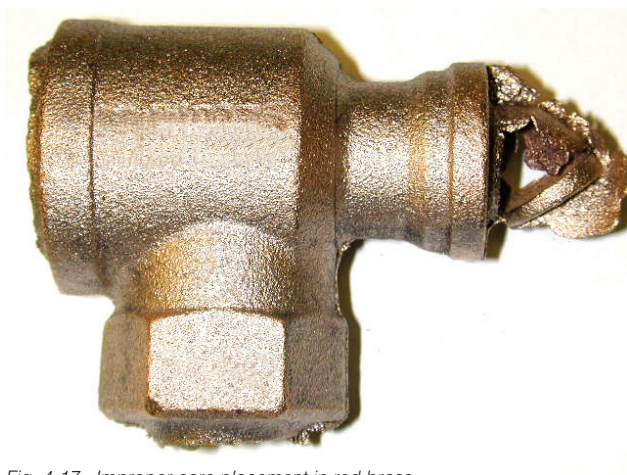


Fig. 4-17. Improper core placement in red brass



Fig. 4-18. Core lift results from inadequate placement; worn core prints allow 'float' in the mold.

CHAPTER 5

Misruns and Coldshuts

Description

A misrun casting is one in which the casting detail is incomplete due to a failure to fill the mold cavity. A portion of the casting may be missing, and/or necessary sharp corners may be rounded. Since these defects are related to casting design and also pouring practice, all casting methods (green sand, chemically bonded sand, permanent and semi-permanent mold) can be susceptible.

A cold shut involves a visual and structural discontinuity due to separate metal flows or where two or more metal streams have come together and fused. This can occur especially in large thin flat sections of the casting.

Both defects result from inadequate pouring practice, although casting geometry, molding equipment, and mold condition play important roles.

Causes

1. Casting Geometry

- Irregular casting sections resulting in interrupted metal flow
- Casting sections too thin relative to metal fluidity
- Isolated thin sections

2. Mechanical and Equipment

- Worn pattern equipment
- Misalignment of pattern equipment
- Core shift
- Weak or improperly reinforced flasks
- Cope or drag shift

3. Sand, Core, Molding Practice

- Excessive moisture
- Sand organic components too high
- Sand too weak causing mold distortion
- Permeability too low creating back pressure
- Inadequate venting
- Improper core size resulting in decreased metal sections
- Excessive mold wash
- Mold and core material with excessive chill reducing metal fluidity

4. Gating, Riser, Pouring Practice

- Inadequate gate and/or runner sizing
- Sprue too small
- Multiple sprues
- Interrupted pouring
- Pour temperature too low
- Inadequate pour height and/or metal pressure
- Pouring too slowly
- Debris in mold hindering metal flow
- Solid debris in metal pour stream
- Poured short (pour volume inadequate)
- Inadequate venting
- Dirty or gassy metal which reduces fluidity



Fig. 5-1. A bronze screw nut cast in green sand shows effects of interrupted pouring.



Fig. 5-2. A cupro-aluminum permanent mold casting exhibits a misrun due to lack of venting.

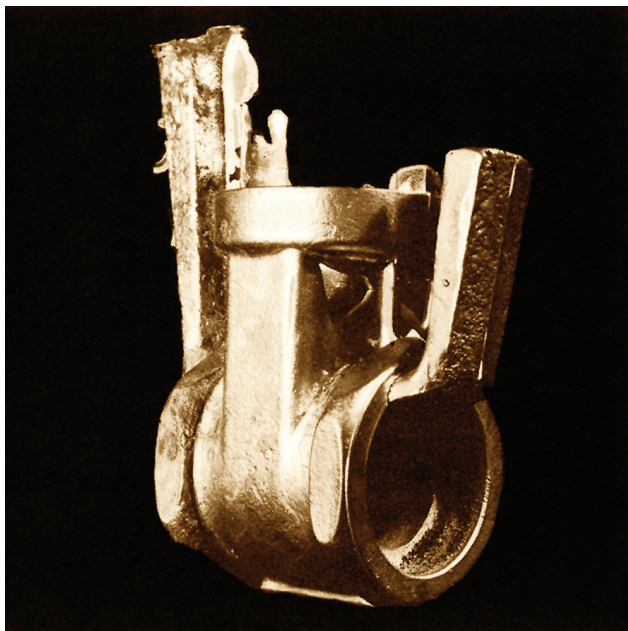


Fig. 5-3. A brass valve body cast in permanent mold shows a misrun caused by entrapped air.

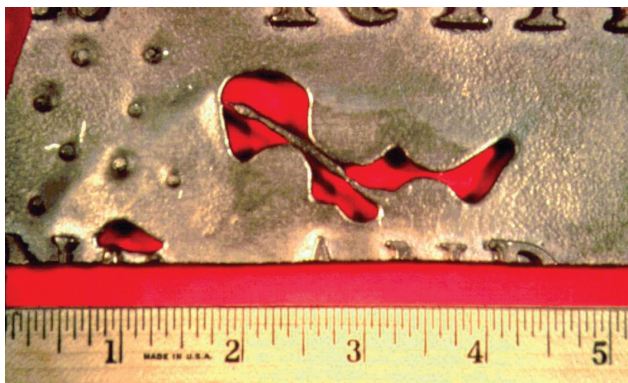


Fig. 5-4. Misrun due to improper gating. When non-pressurized gating was subsequently used, the defect no longer occurred.



Fig. 5-5. Unsatisfactory ingate solidification in leaded red brass.



(a)



(b)

Fig. 5-6. Cold shut and incomplete filling is visible in this red brass casting: (a) left view and (b) right view. Possible causes (any and all) include core gas evolution, inadequate venting, and low pouring temperature.

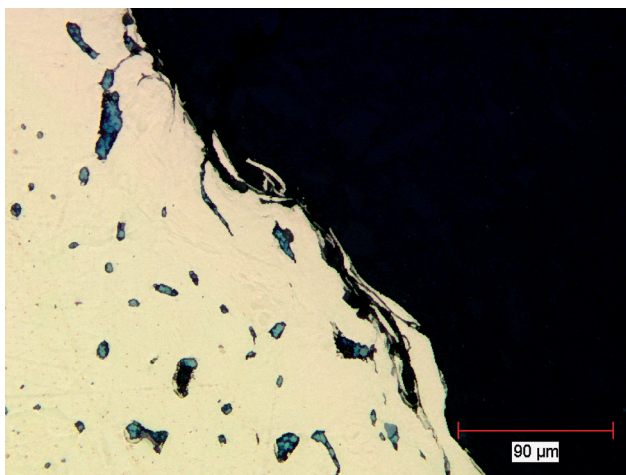
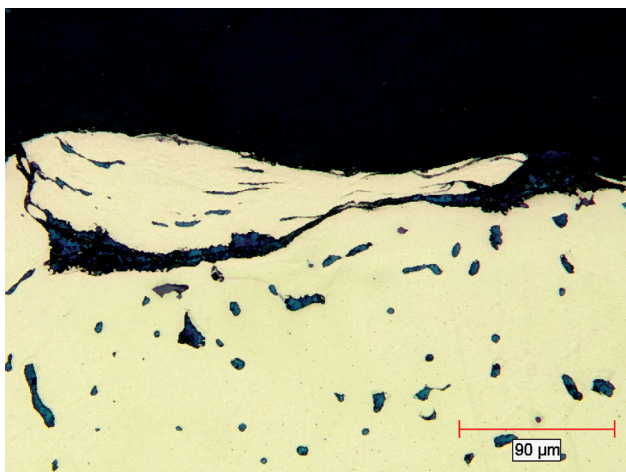


Fig. 5-7. Folds, misrun in yellow brass are due to improper pouring procedure and possible low temperature.



Fig. 5-8. A misrun in red brass is caused by low temperature, inadequate gating and low phosphorus deoxidation.



Fig. 5-9. A red brass casting shows a short pour and inadequate volume.



Fig. 5-10. A dimensionally incorrect red brass casting due to core shift.

CHAPTER 6

Hot Tearing

Description

Hot tearing occurs in nonferrous casting during the pouring and solidification process before the casting becomes completely solid. Physical constraints restrict the casting from normal contraction. Causes of hot tearing are many—casting design, molding practices, pouring and basic metallurgy of the alloy. The crack or tear in the casting is usually interdendritic with an oxidized surface because of the high temperature.

Causes

1. Mechanical and Equipment Related

- Lack of adequate fillets
- Abrupt changes in section thickness
- Flask equipment preventing adequate casting contraction
- Rough handling too soon after pouring

2. Sand, Core, and Molding Practice

- Poor sand collapsibility (strength too high)
- Grain size too large
- Sand too low in combustibles
- Low hot deformation capability
- Vitrification of the sand
- Excessively rigid molds and cores
- Failure to use chills or chills improperly placed
- Delayed shakeout

3. Metal Molds

- Mold open too soon; casting damaged during extraction
- Rough mold surface
- Cores improperly aligned
- Excessive pouring temperature
- Excessive mold temperature
- Poor ejector locations causing bending stresses
- Excessive cooling time prior to knockout

4. Pouring

- Pouring temperature too low to promote collapsibility
- Excessive pouring temperature creating hot spots in thin sections
- Inadequate flow (filling) of liquid metal in the mold cavity
- Cooling too fast
- Shakeout too soon

5. Metallurgical

- Alloy segregation with low melting point metal (tin, lead, zinc) concentrations in last metal to solidify
- Contaminants, tramp elements
- Large grain size



Fig. 6-1. Bronze alloy in dry sand that shows shrinkage extending to surface as a hot tear.

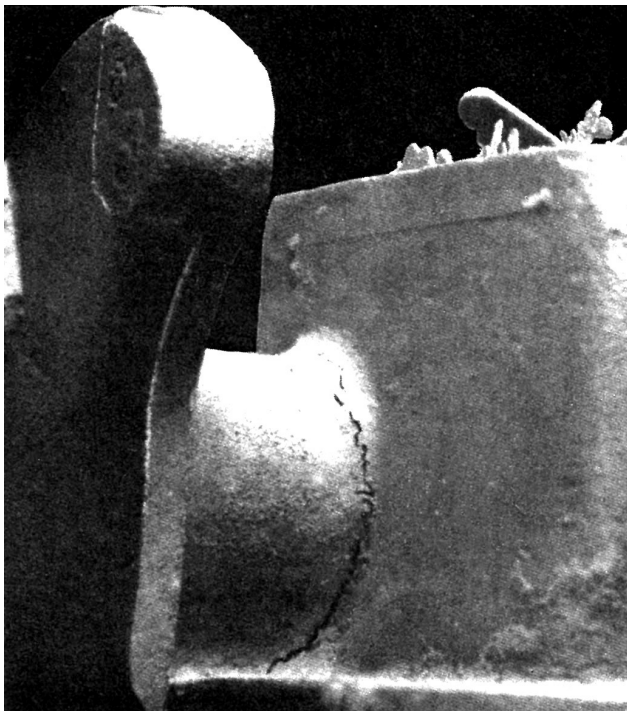


Fig. 6-2. Green sand oil reservoir thin wall casting of 10% Sn, 1% Zn bronze shows a hot tear, caused by restrained contraction.



Fig. 6-3. The hot tear in the brass valve body in green sand is due to restrained contraction and excessive pouring temperature.

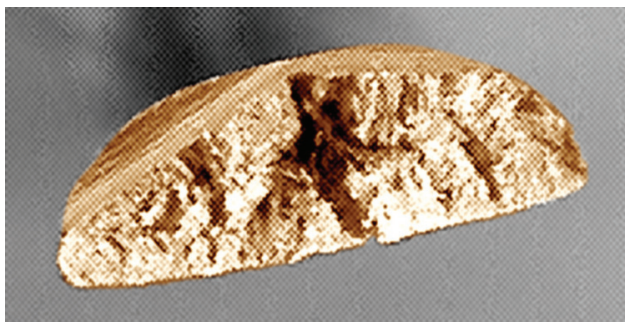


Fig. 6-4. A fracture in red brass cast in green sand exhibits excessive dendrite growth due to excessive melt and/or pouring temperature; venting helps.



Fig. 6-5. Hot tear in red brass caused by shakeout, which is too soon and/or too hot.

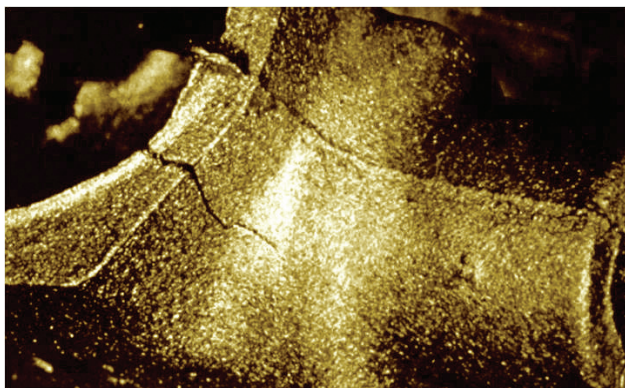


Fig. 6-6. The hot crack in the brass sand casting is due to mold constraint and high pouring temperature.



Fig. 6-7. The hot tear in red brass resulted from the binder content being too high and from mold restraint.



Fig. 6-8. Hot tear in a leaded semi-red brass.

CHAPTER 7

Gas Defects

Description

Gas defects arise from the presence of gas in the liquid metal which forms porosity in the casting as the metal solidifies. The porosity may take the form of a cavity or visual blowhole, pinholes, or blisters. Sources of the gas—which may include hydrogen, air or volatile organics—include gas soluble in the liquid metal, gas arising from moisture in the sand, core outgassing, entrapped air and mold and core wash outgassing. Gas defects are detrimental to machining, surface finishing, and mechanical properties of the casting.

Causes

1. Mechanical and Equipment

- Insufficient mold and/or core permeability
- Lack of adequate venting of mold cavity

2. Sand, Core, Molding Practice

- Moisture content too high
- Poorly mixed sand
- Clay content too high
- Wet coatings
- Inadequate permeability for volatile organic burn-off
- Under-cured cores
- Excessive binder
- Inadequate venting

- Wet core paste
- Absorbed moisture during storage
- Chill or sealing materials not dried
- Excessive gas-producing material in core sand or wash
- Insufficiently dried molds
- Excessive patching
- Hard spots caused by improper ramming for conditions involved

3. Gating, Riser, Pouring

- Wet pouring basins and/or sprues
- Sprue and/or gating system inadequately sized
- Entrainment of air due to turbulence in the sprue and runner system
- Turbulent or interrupted pouring
- Short pours unable to fill mold cavity
- Cold, damp ladles
- Pouring rate too fast or too slow
- High humidity condensation on cold mold sprue and gating system

4. Metallurgical

- Melt too gassy or inadequately degassed and/or de-oxidized
- Excessive melt and/or pouring temperatures
- Metallic impurities in the melt with affinity for hydrogen



Fig. 7-1. A rise is associated with gas porosity in the casting.

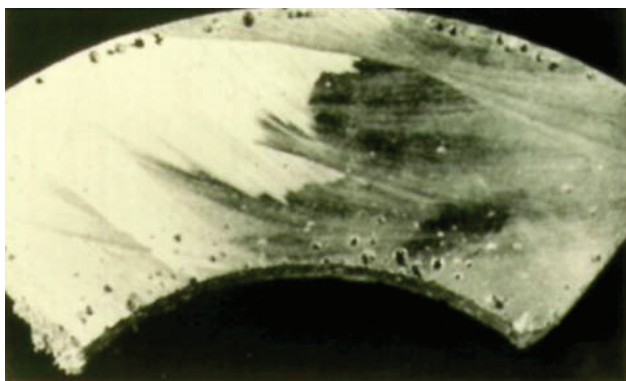


Fig. 7-2. Gassing due to metal mold reaction.

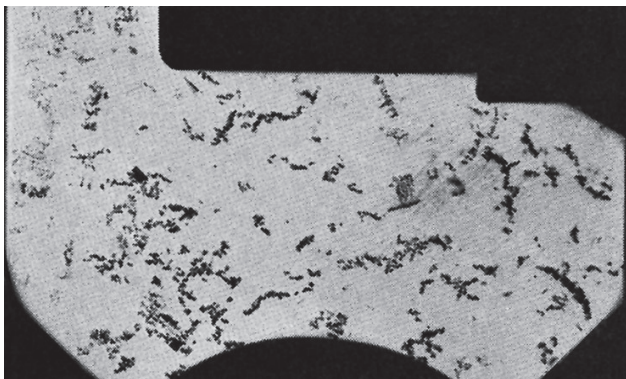


Fig. 7-3. A bronze casting displays macro-porosity.

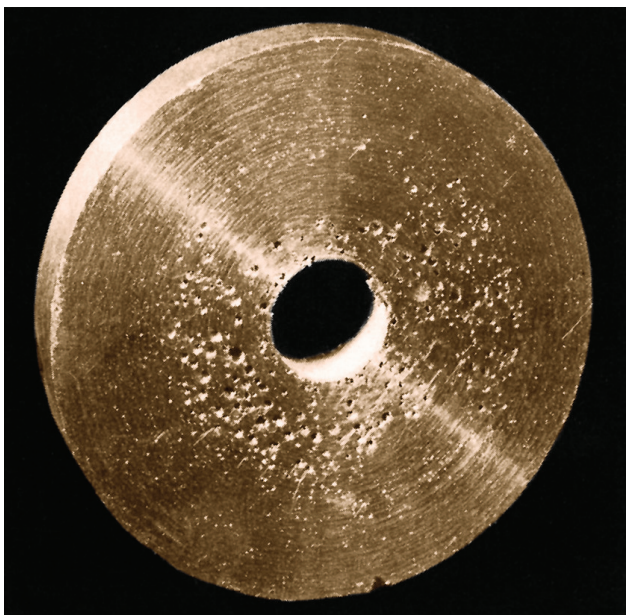


Fig. 7-4. Tin bronze alloy cast in dry sand has blowholes due to gassy melt.



Fig. 7-5. Bronze stopper cast in green sand has blowholes due to gassy melt and/or mold/metal reaction with excessive residual moisture in the sand.

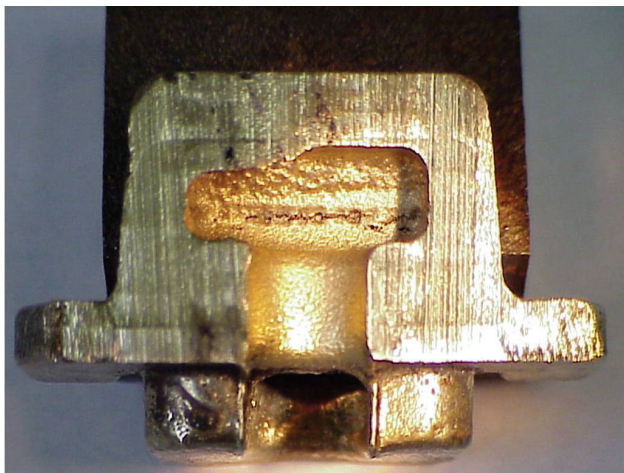


Fig. 7-6. A heavy section of a red brass faucet reveals centerline shrinkage and/or gas porosity.

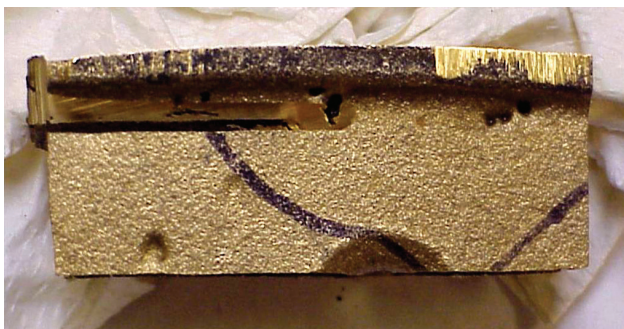


Fig. 7-7. A red brass casting exhibits a gas blow.

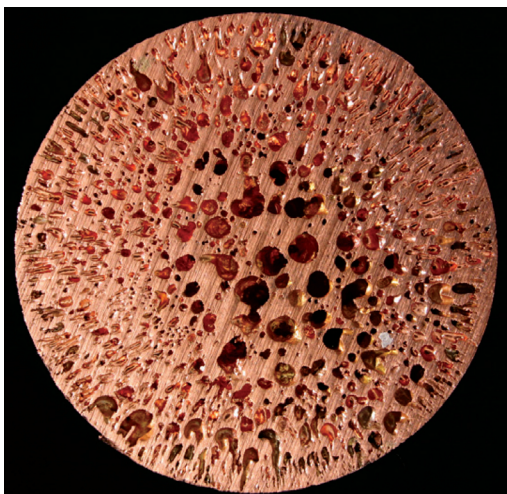
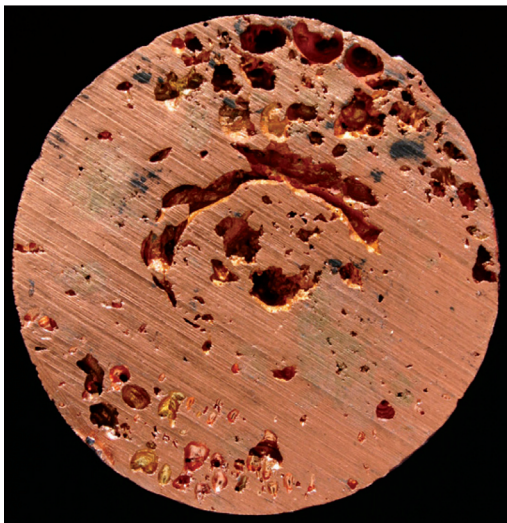


Fig. 7-8. Two views of a high copper casting, exhibiting massive porosity due to poor or no deoxidation and/or degassing.



Fig. 7-9. A discoloration and porosity in red brass is due to gas evolution and high pouring temperature.



Fig. 7-10. X-ray of cast test bar exhibits gross porosity in brass.



Fig. 7-11. Severe gas porosity is seen in red brass.



Fig. 7-12. A copper base casting shows a 'mushroom' gas evolution.



Fig. 7-13. A core gas blow in leaded red brass is the result of poor venting and pouring temperature being too high. Also, inadequate gating causes localized heating at a thick section and a concentrated gas blow within the casting.



Fig. 7-14. A gross blow and dispersed porosity in red brass is the result of a wet core adhesive and improper venting.



Fig. 7-15. Pinholes in aluminum bronze result from inadequate degassing.



Fig. 7-16. The 'mushrooming' copper casting is due to high gas content in the melt



Fig. 7-17. Heavy section brass casting exhibits gas blow during final solidification. Potential solutions are de-gas; provide better feeding; use of chills and lower pouring temperature.

CHAPTER 8

Shrinkage Defects

Description

As a casting solidifies, there is a contraction from liquid to solid state. The casting design geometry should allow for generalized controlled overall shrinkage. Often, however, there is undesirable localized shrinkage. A shrinkage depression or cavity in a casting may form, and may or may not be related to the presence of gas. Shrinkage as a depression on the surface is considered to be macro-shrinkage, while in the interior of a casting there may be dispersed or micro-shrinkage. Macro-shrinkage is usually associated with or surrounded by a cast interdendritic structure, often spongy, and is related to inadequate mold filling. Micro-shrinkage takes the form of pinholes or small cavities within the interdendritic network. Micro-shrinkage often occurs in the last section of the casting to solidify and also may be related to gas content evolving during solidification as well as inadequate feeding.

Causes

1. Mechanical and Equipment

- Abrupt changes in casting section thickness
- Inadequate fillets
- Insufficient feeding
- Insufficient cope height

2. Sand, Core, Molding Practice

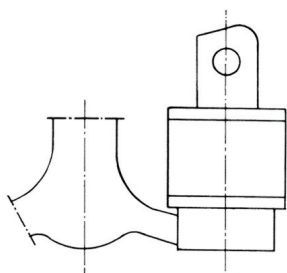
- Wet sand
- Low compressive strength
- High hot deformation
- Core shift
- Weak cores
- Lack of fillets
- Soft ramming
- Mold wall movement under pouring pressure

3. Gating, Riser, Pouring

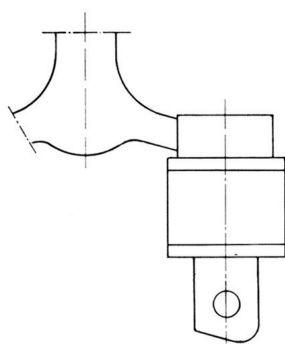
- Inadequate riser volume
- Insufficient riser placement
- Lack of necessary chills
- Need for exothermic riser compounds or sleeves
- Pouring too hot or too cold
- Failure to top off risers with hot metal
- Incorrect gating for part design



Fig. 8-1. Brass sand casting shows centerline shrinkage crack. Lowering iron and tin content, increasing riser size and reducing pouring temperature would eliminate the shrink.



(a) Existing Gating



(b) Better Solution

Fig. 8-2. Permanent mold cupro-aluminum casting exhibits shrinkage cavity due to inadequate feeding through bottom gating into the heavier section.



Fig. 8-3 Centerline shrinkage in red brass is caused by insufficient feeding.



Fig. 8-4. Severe macroshrinkage in leaded red brass is caused by too low of a pouring temperature and/or insufficient feeding.



Fig. 8-5. Shrinkage porosity in red brass is caused by poor solidification (low pouring temperature, inadequate feeding).



(a)



(b)

Fig. 8-6. Sink and shrinkage crack in permanent mold cast gunmetal resulted from the temperature being too low and from mold coating erosion: (a) crack in casting; (b) defect magnified.



Fig. 8-7. Shrink in semi-leaded red brass resulted from incorrect pouring temperature and inadequate risering.



Fig. 8-8. Casting shows shrinkage from inadequate ingate solidification.

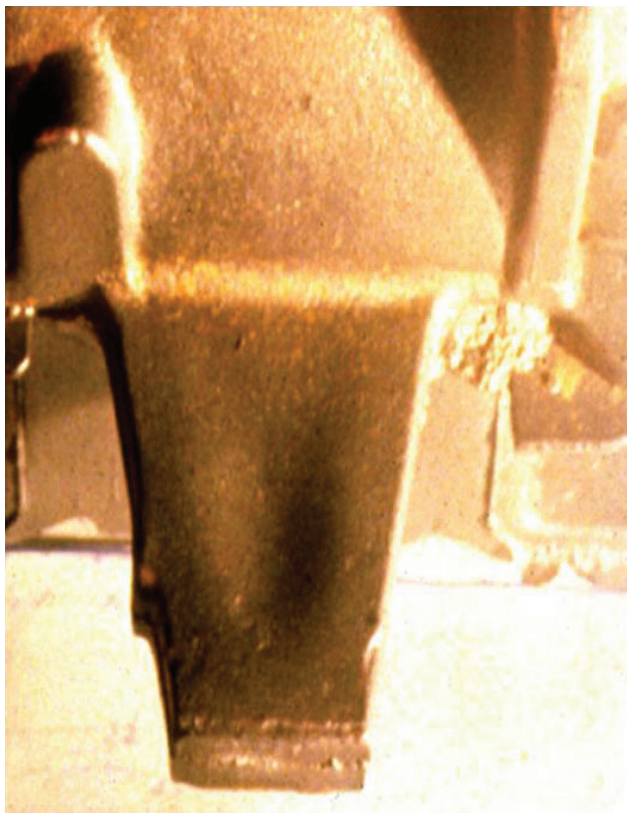


Fig. 8-9. Surface sink is due to lack of feeding; uniform shrinkage occurs without rupturing the surface.

CHAPTER 9

Metal Penetration

Description

Metal penetration defects occur in the sand casting process due to high fluidity of the liquid metal and weakness in the mold surface. A somewhat less insidious interaction between the liquid metal and the mold is burn-on, which is a strongly adherent crust of sand. A visual discoloration of the mold surface results, as well as localized increased grain size in the microstructure, which may or may not be detrimental depending upon the casting's utilization. Burn-on sand must usually be removed by grinding rather than blast cleaning.

Causes

1. Mechanical and Equipment

- Sharp corners

2. Sand, Core, and Molding Practice

- Poor sand mixing
- Irregular grain size distribution leading to poor ramming
- Low mold density
- Excessive mold permeability
- Soft cores
- Incorrect core material
- Rough core surface
- Insufficient core binder or curing

- Poorly patched areas
- Excessive usage of parting compounds
- Uneven mold coating application

3. Gating, Riser, Pouring

- Too close positioning of gates and risers promoting overheating of the sand
- Pouring too hot
- Excessive pouring height
- Turbulent metal flow during pouring



Fig. 9-1. A bronze alloy in green sand exhibits burn-on.

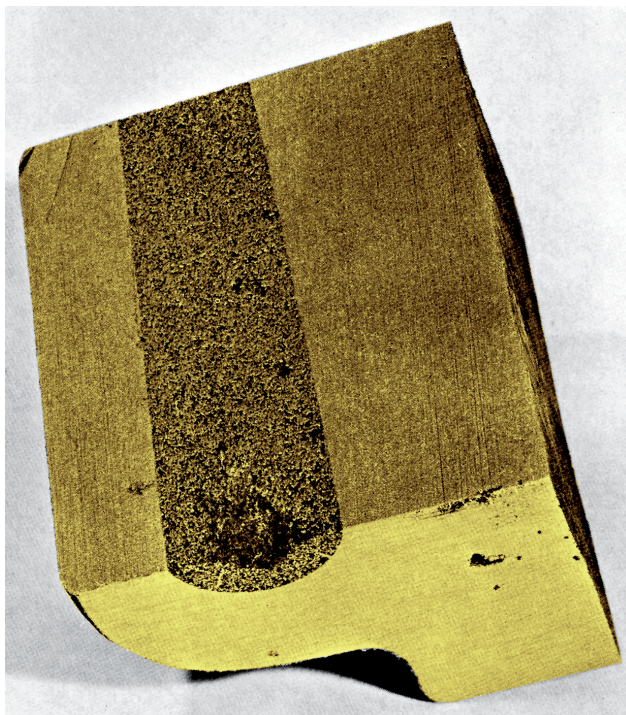


Fig. 9-2. A bronze alloy in dry sand exhibits metal penetration at the core despite use of a core wash. The remedy is to switch to shell core.

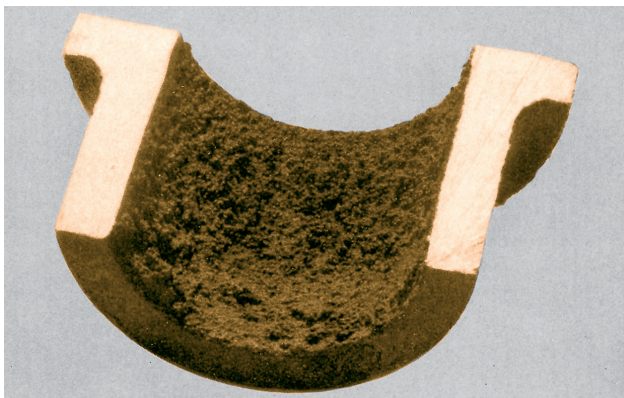


Fig. 9-3. Phosphor bronze green sand casting shows uniform penetration due to low surface tension liquid metal and lack of proper core wash coat (graphite). The solution is to employ higher density sand with higher thermal conductivity to enhance faster solidification.



Fig. 9-4. The casting shows a burn in or metal penetration caused by improper sand mixture, excessive metal fluidity, and pouring temperature.

CHAPTER 10

Inclusion Defects

Description

Inclusion defects occur as the existence of insoluble particulate material trapped within the casting during solidification. Inclusions arise from the melting process; from contaminants; from fluxes and other melt treatment product debris; from breakdown of furnace and ladle refractories; from breakdown of mold and core materials and coatings during pouring and from turbulent pouring. Inclusions may be oxides or intermetallic compounds, dross or slag. Grain refining practices can create hard intermetallic constituents. Machining, surface finishing operations and mechanical properties are usually compromised by the presence of inclusions.

Causes

1. Mechanical and Equipment

- Casting design factors that contribute to metal flow problems in sand molds will increase tendency for inclusions to form
- Casting pattern design that prevents inadequate molding will increase tendency for loose sand to become entrapped within the casting
- Rough handling of molds and flasks
- Gouging of the mold during closing or core setting
- Inadequate venting

2. Sand, Core, and Molding Practice

- Inadequately mulled sand
- Sand grain size too irregular
- Inadequate molding resulting in low strength
- Metal-mold reaction
- Weak cores
- Excessive and/or improperly cured mold and core wash coatings

3. Gating, Riser, Pouring

- Gating systems which create turbulent flow
- Turbulent pouring
- Dirty ladles
- Inadequate dross separation from the melt prior to pouring
- Weak ladle refractories which spall during pouring
- Intermittent pouring
- Excessive pouring temperature

4. Melt and Metallurgical

- Tramp element impurities in excess of solubility limit, forming inter-metallic inclusions
- Charge mix with excessive fines and/or oxides
- Flux inclusions
- Melting furnace refractory erosion
- Excessive melt temperature
- Inadequate de-oxidation of the melt

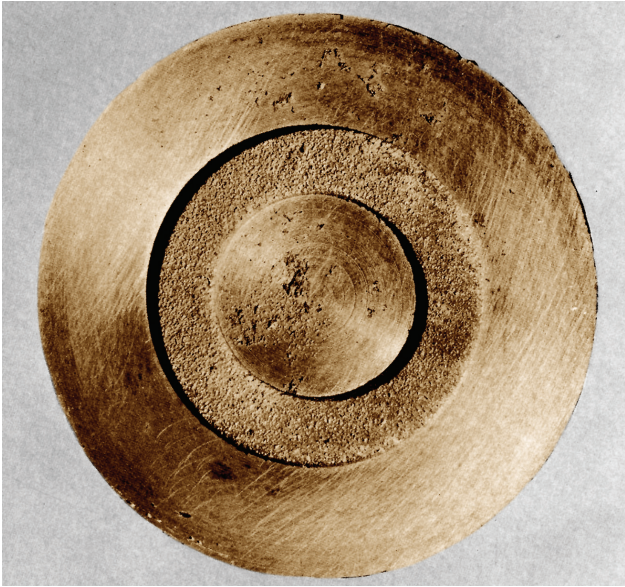


Fig. 10-1. Brass casting contains dross inclusions.



Fig. 10-2. Bronze valve body cast in green sand shows sand inclusions caused by core erosion.

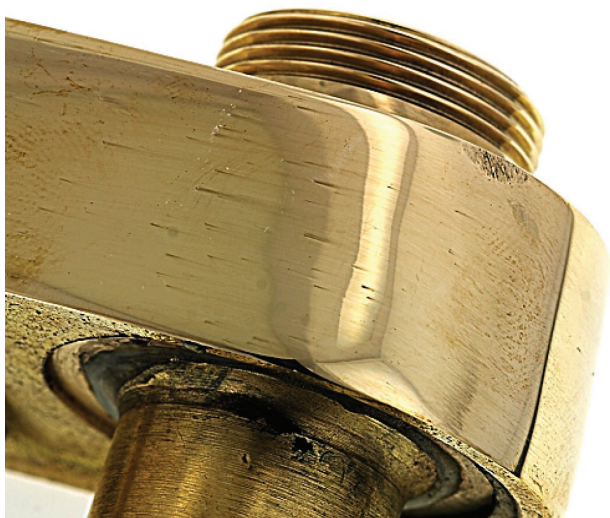


Fig. 10-3. The yellow brass has a comet tail blemish on the polished surface after machining. Possibly an iron-boron inclusion resulted from grain refining with boron.

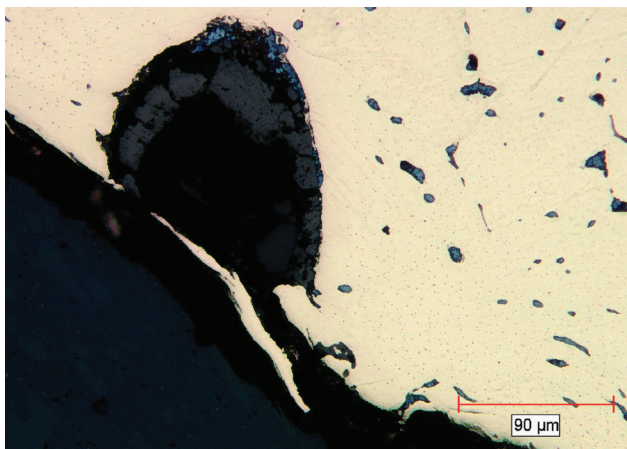


Fig. 10-4. A trapped sand grain is seen in yellow brass. Mold erosion due to turbulent pouring and/or weak sand.

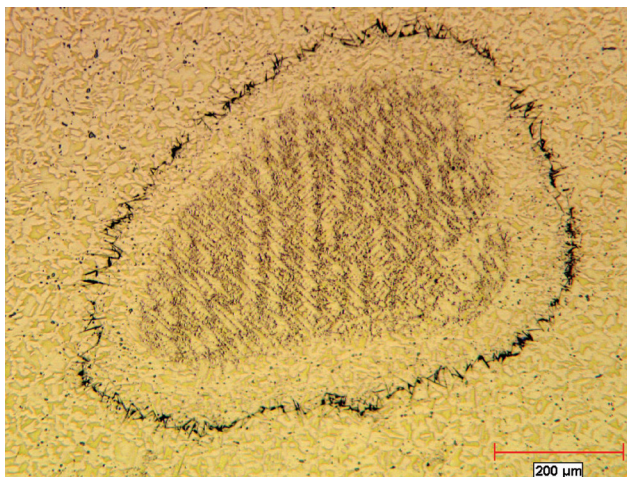


Fig. 10-5. Hard iron-containing particles in yellow brass are commonly found when grain refining with boron; controlling iron below 0.05% is a remedy.



Fig. 10-6. A macro-inclusion in brass casting is a possible refractory vessel erosion.



Fig. 10-7. Poor surface on aluminum bronze casting is due to excessive dross formation and lack of removal prior to pouring.

CHAPTER 11

Other

Description

Another defect which can occur in copper alloy casting relates to low temperature metal alloy constituents (lead, tin), that segregate during latter stages of solidification and exude from the surface of the casting. Exudation of the residual liquid occurs due to forces of contraction and the pressure of released gas. This surface defect is often accompanied by microporosity. An example is tin sweat.

Flaring, or zinc flaring, is manifested as a surface visual defect that may also be accompanied by an excessive reduction in zinc content in the casting. This occurs predominantly in yellow brass alloys. It is due to excessive melt and pouring temperatures.

Cracked castings prior to service may arise from severe stress on the part due to machining. Any alloy segregation or inclusions may exacerbate this problem.



Fig. 11-1. Leaded tin bronze cast in green sand. Sprue exhibits tin sweat.

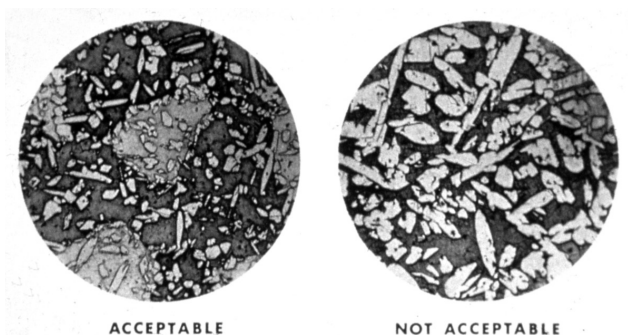


Fig. 11-2. Unacceptable manganese bronze microstructure had less zinc, even after a make-up addition, and exhibited lower mechanical properties.

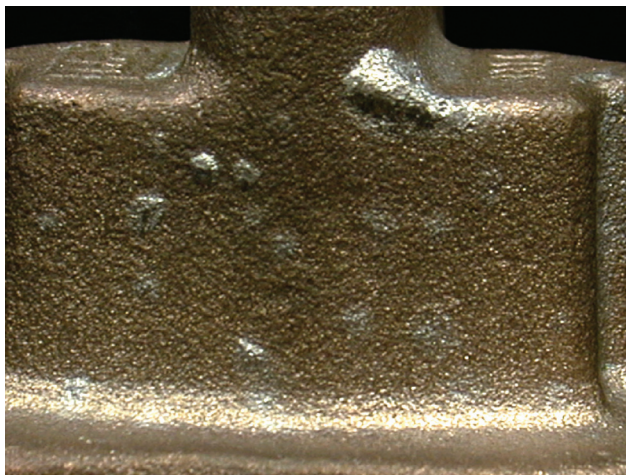


Fig. 11-3. Red brass exhibits tin sweat, caused by long solidification and gas evolution. Proper degassing and directional solidification are remedies.



Fig. 11-4. Yellow brass casting crack, observed after machining, is possibly due to severe residual stress and/or temperature state during machining.



Fig. 11-5. Lead-free brass casting, cracked during machining, is caused by severe stress and heat.



Fig. 11-6. Overblast damage on brass casting is due to excessive shot or grit casting cleaning.

APPENDIX

International Defect Codes, Names and Corresponding Chapter(s)

International Defect Code	Defect Name	CDHB Chapter
B112-GI	Blowholes next to Inserts/Chills	N/A
B111-GI	Blowholes, Pinholes	7,8
C111-GI	Breakage	N/A
E221-GI	Broken Casting	1
A226-GI	Broken or Crushed Core	N/A
D131-GI	Buckle	7
D222-GI	Burn In	9
D221-GI	Burn On	N/A
F233-GI	Casting Distortion	N/A
G211-GI	Chill	1,5-8
D224-GI	Coating Failure	N/A
C331-GI	Cold Chill or Insert	N/A
G112-GI	Cold Shot	N/A
C311-GI	Cold Shut or Cold Lap	5
D112-GI	Cope Defect, Elephant Skin	N/A
D232-GI	Cope Erosion Scab	N/A
A121-GI	Cope Raised, Raised Mold	N/A
B213-GI	Core Shrink	N/A
B212-GI	Corner or Fillet Shrinkage	1,3,4,8
A225-GI	Corner Scab	6
A213-GI	Crush	4
B124-GI	Dispersed Shrinkage	N/A
B122-GI	Draws	N/A

A212-GI	Erosion, Cut or Wash	4
A114-GI	Fillet Scab	3
A115-GI	Fillet Vein	N/A
D114-GI	Flow Marks	2
D133-GI	Flow Marks, Crow's Feet	N/A
G144-GI	Hard Spots	7
C121-GI	Hot Cracking	1
C221-GI	Hot Tearing	6
B221-GI	Internal Shrinkage	8
G262-GI	Kish Graphite Inclusions	N/A
G223-GI	Localized Hard Spots/Chilled Areas	7
G143-GI	Lustrous Carbon Films	N/A
D223-GI	Metal Penetration	9
G111-GI	Metallic Inclusions	10
E111-GI	Misrun	5
A224-GI	Mold Drop	N/A
B211-GI	Open or External Shrinkage	8
D134-GI	Orange Peel, Alligator Skin	N/A
E122-GI	Poured Short	5,7
D211-GI	Push Up, Clamp Off	1
F223-GI	Ram Off, Ram Away	N/A
D132-GI	Rat Tail	3
D121-GI	Rough Casting Surface	4
E123-GI	Runout	3
A122-GI	Sag or Strain	4
G131-GI	Sand Inclusions	10
D231-GI	Scab, Expansion Scab	3,4
F221-GI	Shift	2,5,8
F222-GI	Shifted Core	5
D141-GI	Sink Marks, Draw, Suck In	N/A
B113-GI	Slag Blowholes	4,8
D142-GI	Slag Inclusions	10
G121-GI	Slag Inclusions, Dross, Cerioxide	10
A221-GI	Sticker	1,4
D111-GI	Surface Folds	N/A
B123-GI	Surface Pinholes	7

A211-GI	Swells	4
G221-GI	Type C Graphite	N/A
G222-GI	Unacceptable Skin	N/A
A112-GI	Veining or Finning	3
F234-GI	Warped Casting	N/A
F	Off Dimension	2
B	Gas Voids with MnS	N/A
B	Gas Voids Lined with Graphite	N/A
B	Gas Voids Lined with Oxide	7
G	Micro-voids Lined with Steadite	N/A
G	Tellurium Wash Migration	N/A
G	Carbide/Inverse Chill	N/A
G	Carbide-Intercellular Primary	N/A
G	Carbide Intercellular alloy	N/A
G	Widmanstätten Graphite	N/A