

CATEGORY: ROLL SURFACE INDICATIONS
TYPE: PIN HOLES AND POROSITIES
AFFECTS: WORK ROLL AND BACK UP ROLL (HOT MILLS and COLD MILLS)

CHARACTERISTICS

Pinholes and porosities are characterized as small randomly scattered open holes at the surface and/or subsurface of the roll material. The indications can vary in the following characteristics depending on the source and cause:

- Shape (round, linear or irregular)
- Interior Texture (round/smooth or rough/dendritic)
- Size (microscopic up to several millimeters)
- Depth (microns to several millimeters)
- Quantity (one to numerous)
- Distribution (randomly scattered or concentrated)

EXAMPLE



Example 1

Small, round, smooth porosities present at the barrel surface of a work roll.

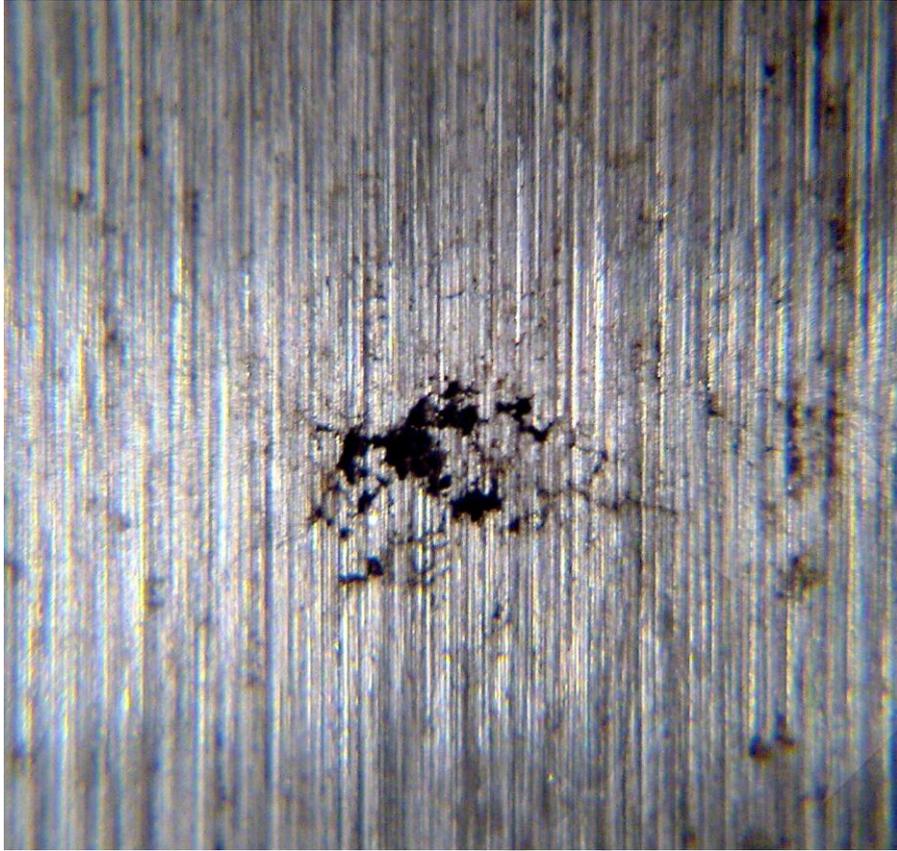


Figure 2

Small, irregular shaped, rough texture porosity present at the barrel surface of a cast steel back up roll.
X20 magnification

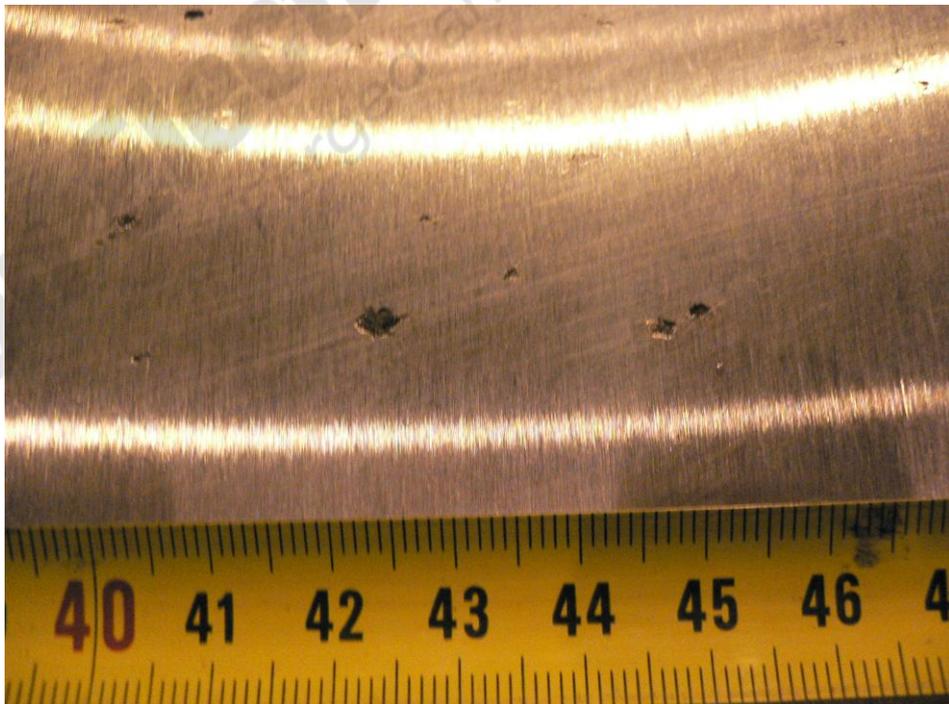


Figure 3

Small, round, semi-rough texture porosities at the barrel surface of a steel back up roll.

GENERAL MECHANISM

Pinholes and porosities can result from several diverse mechanisms but are always related to manufacturing. Round smooth pinholes will typically result from gas entrapment in the solidifying liquid metal. Entrapped gas can be present in the melt, evolve from the mould coatings or be present within firecracks in the mould chill walls.

Dendritic porosities are typically irregular shaped cavities with rough dark interiors. Porosities will form due to poor interdendritic feeding during solidification of the roll casting.

PREVENTION

The presence of pinholes and porosity at the barrel surface or subsurface of a roll are unlikely to result in serious or catastrophic failure, however they may result in inspection problems and possibly in small, shallow spalling of the effected roll (only in severe cases). It is highly recommended that any roll exhibiting pinhole indications (gas entrapment) or large porosity indications (> 2mm in diameter) be reported to the roll supplier for recommended corrective action. A few, evenly distributed, small porosity indications (<1 mm) are typical of large static castings (back-up rolls) and are not known to result in any quality issues.

Pinholes and porosity are the responsibility of the roll manufacturer and as such the roll maker should:

- Ensure that process control measures are in place to ensure proper control of the solidification front and that all moulding materials are properly mixed and thoroughly dried.
- Carry out inspection prior to shipment of a roll to ensure the barrel surface and the working layer are free from pinholes and porosity indications. It should be noted, however, that subsurface pinhole and porosity indications may be difficult to detect using standard inspection methods.

MECHANISM IN DETAIL

Pinholes and porosities occur during solidification of the roll material and can result from several diverse mechanisms:

➤ **Gas Entrapment (pinholes)**

Small, round, smooth textured pinholes will typically result from gas entrapment in the solidifying liquid metal. Gas entrapment can occur via the following mechanisms:

- Gas can be present as a solute in the molten metal which then evolves as a gas “bubble” and becomes entrapped when the metal solidifies and solubility limit of the gas in the metal is reduced. This type of pinhole can be present through the entire cross section of the affected roll material.
- Gas can be emitted directly into the molten metal from the improperly dried mould materials, mould coatings (paint) or can be from gas emission from improperly mixed resin bonded sands as well as poor mould condition (firecracks). This type of pinhole is typically isolated to the near surface areas and can therefore be typically fully removed.

Gaseous pinholes are typically small, round and smooth textured inside. The shape and texture are characteristic of what would be expected for an entrapped “bubble” of gas. Due to the mechanism of formation, they can range from one indication to a few and can be randomly distributed or concentrated within an affected area.

➤ **Solidification Micro-shrinkage (porosity)**

Micro-shrinkage porosities form during solidification due to poor interdendritic feeding. There can be multiple reasons for poor interdendritic feeding, however the most common causes are:

- Solidification front interruption
- Improper nucleation resulting in excessive dendritic arm spacing.
- Slow solidification rate - this can be caused by casting too hot and or from too much chill insulation (sand thickness).

Micro-shrinkage porosities are typically irregular shaped cavities with a “rough” (dendritic) interior. They can range in size from very small (< 1mm) to large in severe cases (>10mm) and depending on the root cause can be distributed over the entire circumference or concentrated within an affected area.

Due to their typical shallow depth and even distribution, large micro-shrinkage porosities (2 – 5mm in diameter) in back-up rolls do not usually result in catastrophic spalling. However, they can be detectable during eddy current and ultrasonic inspection which can cause difficulty in trying to detect true cracks. If present on the barrel surface of a work roll, large micro-shrinkage porosities can affect the strip surface quality if the transferred indications are unable to be rolled out with successive stands.

If the porosities are too large (>5mm in diameter), extend to a measurable depth (>5mm) and/or are clustered together in a small area, the stress concentration effect can result in contact stress crack initiation and propagation which could eventually result in small shallow spalls on the roll barrel surface.

Very small (<1mm), well scattered micro-shrinkage porosity indications are actually quite common in the near surface region of large scale static castings (such as back-up rolls). As these common sort of micro-shrinkage porosities do not result in any known quality issues and are not likely to result in a catastrophic fracture, these indications do not need to be removed if found using common inspection tests such as visual inspection dye penetrant (they are generally not detectable using eddy current or ultrasonic).

As the root cause and severity will determine what action (if any) is needed for a roll exhibiting micro-shrinkage porosity, corrective actions for individual rolls should therefore always be discussed with the roll supplier.

A large, light gray watermark is oriented diagonally across the page. It features the text "Union Electric Steel" in a bold, sans-serif font, with "Forged and Cast Rolls" in a smaller font below it. The watermark is partially overlaid by a stylized graphic of a roll of steel with a white and gray striped pattern.

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