Some project specifications state in one form or another that "*Anodes shall be free from flaws or defects. Surface blemishes or depressions, and internal slag, dirt, and porosity, shall be cause for rejection."*

For both practical and economic reasons, such "perfection" clauses should be avoided. Anodes, in most instances, are not as critical as aircraft parts or nuclear components. They are "commercial castings". Whether sand cast, or centrifugally or statically "Chill Cast", they will contain flaws. Not all flaws materially impair *fitness for use*. Experience has shown that over many years manufacturers have reliably supplied anodes that performed well. Therefore, the focus of inspection should be upon fitness for use not perfection, in acknowledgment of sound judgment by inspectors. Recognizing this principle, BS 1591:1975, includes this practical wording:

> *The castings, as delivered to the purchaser, shall be free from defects* ***which may impair the performance of the finished component****.* (emphasis added).

The following definitions are intended to assist communication between inspectors and anode suppliers when defects are of concern.

## DEFINITION OF DEFECTS RELEVANT TO CHILL CAST ANODES

### 1. PURPOSE

This document defines and describes defects that may occur in Anotec Chill Cast Anodes, and is intended as a training aid for plant and third party inspectors.

**2. REFERENCE:** "Analysis of Casting Defects: American Foundrymen's Society, 3rd Edition, 1st Revision."

| ITEM | CATEGORY/DEFECT NAME | REFERENCE CHAPTER / PAGE |
|---|---|---|
| 3.1 | Carbon Floatation (Kish) and Other Gross Segregation's | 3 / 6 |
| 3.2 | Dirt, Slag and Other Inclusions | 6 / 16 |
| 3.3 | Gas Defects | 11 / 42 |
| 3.4 | Hot Tears (Cracks) | 13 / 56 |
| 3.5 | Cold Shuts (Seams) | 18 / 74 |
| 3.6 | Shifts | 26 / 104 |
| 3.7 | Shrinkage Cavities | 28 / 111 |
| 3.8 | Fins | 31 / 125 |
| 3.9 | Warped Castings | 32 / 129 |

## 3. DEFINITION OF DEFECTS RELEVANT TO CHILL CAST ANODES

**3.1 Gross Segregation "Kish"** is free graphite (carbon) which has separated from molten iron as a function of cooling rate and chemical composition. The closer the percent carbon (and silicon) to the maximum solubility, and the slower the cooling rate, the more likely Kish will float to the top surface of the casting. Chill Cast Anodes, cooled very rapidly, are less likely to have Kish than slowly cooled Sand Cast Anodes. This defect is uncommon in Chill Cast Anodes.

**3.2 Dirt, Slag and Other Inclusions** are particles of foreign material embedded in the metal, which if at the surface may be removed during cleaning, leaving only craters. Dirt may include sand from the molds or cores. Chill Cast Anodes require less sand than Sand Cast Anodes. Slag, always formed in melting of metal, is usually lava like material such as oxides of silica and other alloys in the melt. Slag tends to rise to the top of molten metal, and in Anotec Chill Cast Anodes, if found, will usually be in the vicinity of the "Anotec Canada" ingate location on one end of the Anode.

**3.3 Gas Defects** are usually smooth walled cavities; spherical, flattened or elongated. They may appear as craters if so close to the surface that the metal skin has been removed in cleaning.
Gases may enter the metal through turbulent pouring, or by higher gas pressure in the mold than fluid pressure in the molten metal. Many other sources of gas exist. Metal molds for Chill Cast Anodes are less likely to create gas defects than sand molds bonded with water and chemical binders which convert to high-pressure gas when subjected to molten metal.
Gas defects, may form as elongated cavities extending from the tip of the connection cavity into the center of the anode. Anotec pours chill molds horizontally, to minimize turbulence, since the molten metal stream falls only a few inches before entering the mold.

**3.4 Hot Tears (Cracks)** are usually thin sharp edged cracks in Silicon Iron anodes. If the anode is broken at the crack, the surface will be discoloured (oxidized). In Chill Anodes, tears are usually circumferential and may cause breakage in shipment or handling if undetected during factory inspection.
Anotec's proprietary process creates a metal microstructure with superior resistance to cracking or breakage under impact. Nevertheless, Silicon Iron is a brittle material which does not absorb impact energy as well as steel.

**3.5** **Cold Shuts** are definite discontinuities due to imperfect fusion where two streams of molten metal converge. The defect usually appears as a crack or seam with smooth, rounded edges. The shuts may be circumferential or longitudinal, usually away from the Anotec connection head. Usually, cold shuts in Chill Cast Anodes are very thin surface defects which can be easily removed by grinding.

**3.6** **Shifts** are mismatches of the casting at the parting line between the two halves of the mold.

**3.7** **Shrinkage Cavities** are jagged holes or spongy areas with a rough lining. (Gas cavities are smooth lined). Shrink is usually found at heaviest section, at changes of a section, or near to the ingate. (nominally 2" diameter feeder core marks).

**3.8** **Fins** are thin plate like protrusions of metal from the surface of the casting, usually with smooth rounded edges as cast, but which when broken may be sharp.

**3.9** **Warping** refers to the tendency of the casting to bow as it cools. Anotec uses unique proprietary procedures to mitigate warp, and to inspect for compliance with expectations and fitness for use.