Specialist
CASTINGS LIMITED

A DIRECT COMPARISON OF CENTRIFUGALLY CAST TUBULAR ANODES AND DIE CAST TUBULAR ANODES

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The best way to verify the integrity of the sub-surface structure of a casting is by x-ray. By taking x-ray shots along the length of the casting to ASTM E94 it is possible to view images of the structure and therefore universally define the overall integrity of the casting. X-ray acceptance standards ASTM E186 and ASTM E446 list defects from severity level 1 (the best level) down to level 5 (the worst level).

WHAT IS THE SIGNIFICANCE OF DEFECT LEVELS?

By examining the quality levels 1 to 5 that are exhibited by the anodes, it is quickly possible to understand how the theoretical design life of the anode system will be affected. If the x-ray testing determines the casting flaws are level 1, then no Cathodic Company or end user has, to anyone's knowledge, found the life of the anode system to be cut short by any significant time span. This is not surprising when many high integrity items used in medical and aerospace environments accept castings exhibiting level 1 defects.

At level 2 acceptance criteria, there are some specific flaws that will influence the overall life of the anode, however, the size and frequency of these flaws are sufficiently small that their existence does not immediately necessitate the need for the casting to be scrapped. The x-ray acceptance criteria should (and does) take in to account both the size, frequency and type of defect present.

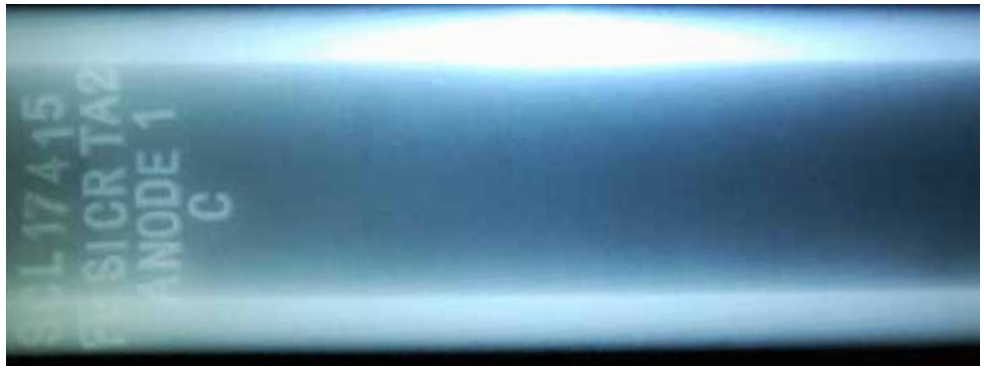
COMPARISON RESULTS

This x-ray shows a die-cast anode.

Scattered shrinkage surrounding pouring cup area

Circular shadow showing shrinkage level 3 positioned under pouring cup.

The below x-ray shows our centrifugally-cast anode.



Straight Wall Centrifugally-cast Anode, showing no visible defects. Therefore, better than Level 1 X-Ray.

In the top x-ray (of the die-cast anode) dark circular shadows depicting sub-surface shrinkage can be seen around the area of the pouring cup, i.e. where the metal has been poured in to the anode. These shadows are depicting an area of shrinkage and it is clear from the image that the area around the pouring cup also contains additional fragmented pockets of shrinkage seen as 'dark patches' scattered away and around the pouring cup position. In the image, this area has been defined as a level 3 defect. If an accelerated corrosion test was carried out on the whole anode, then this area would be consumed at a faster rate than the remainder of the anode. Furthermore, these areas around the pouring cup and riser have historically been the source of fissuring and cracking of the anode causing premature failure.

Likewise, if a mechanical test bar was machined out of this section of the casting, the results would fall far short of those exhibited by any section of the centrifugally cast anode. We have retained these pieces for further testing by any interested party, if so desired.

At acceptance criteria level 3 the casting may not perform correctly. Although the silicon iron material retains gas porosity by its very nature which is measurable through x-ray analysis, if the anodes are produced to level 3 then there are additional flaws in the manufacturing procedure which are quantifiable and ideally should not be accepted. Likewise at levels 4 and 5, these flaws are progressively abundant and the design life will be dramatically curtailed.

Although in the 1970's, Jacobs and Hewes carried out some very basic accelerated corrosion testing on Silicon Iron Anodes, there is no industry standard that categorises this foreshortening of anode life against x-ray standards. The results by Jacobs and Hewes were primarily initiated in order to evaluate silicon iron consumption rate and not to evaluate the silicon iron castings themselves. It is our intention to carry out these Accelerated Corrosion Tests.

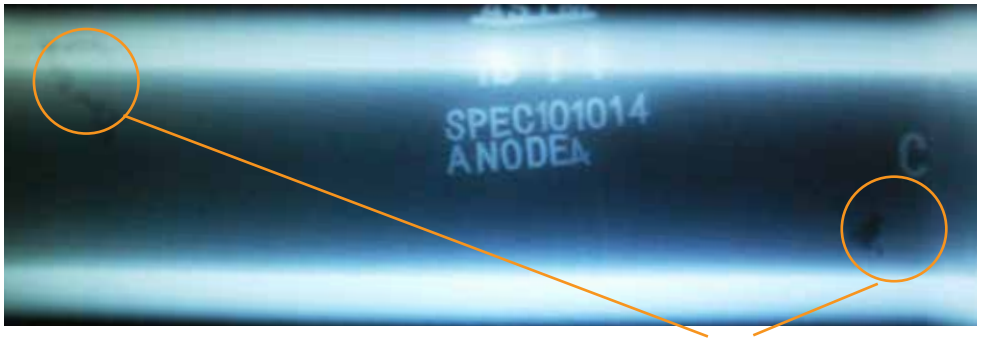
The table below represents the most up to date summary for assessing the design life against the x-ray level acceptance criteria. Some companies, such as the ENI Group simply state their refusal to accept any anodes that are below level 3 and other companies have based their design life on their own experience and installations.

X-Ray Level	Design Life
Level 1	100%
Level 2	80-100%
Level 3	60-80%
Level 4	20-60%
Level 5	<20%

It should be noted that the type of defect seen on the x-ray and its position in the casting will further influence the design life. For instance; a linear shrinkage defect in the wall of the casting may well cause a more dramatic reduction in life if it causes the part of the anode to fissure or tear along its axial length when in use.

Additionally, the centrifugally cast anode utilises a straight-walled anode design that has no change in cross section or thickness at the centre of the anode and no complex arrangement of sand cores (die cast anodes require up to 10 sand cores per anode) which are susceptible to individual discrepancies between every casting.

This x-ray shows a die-cast anode.



This change in section is an inherent weakness in the design of a die-cast anode because the change in wall thickness means the thicker part of the casting cools more slowly than the narrow section. This slower cooling rate not only causes an inferior grain structure that is almost as poor as sand-cast anodes, but also necessitates an additional riser to help feed the shrinkage that is catalysed from the change in section. The x-ray image of the die-cast anode above shows a serious casting flaw visible as a dark shadow in the connection area and is a real-life sample confirming the difficulties encountered with this design.

By comparison, any impurities in a centrifugal casting are thrown to the bore of the casting by application of Stoke's law and are thus not detrimental to the life of the anode. This is a unique feature of the Centrifugal Casting method and is highly advantageous to the integrity of the casting.

HOW TO USE X-RAYS AS A TOOL FOR ORDERING

Many companies are now specifying that anodes should be supplied that pass an x-ray test to level 1, level 2 or level 3 ASTM E186. Although it is not economically viable to carry out an x-ray test on every anode, it is possible to demand that anodes supplied should pass an x-ray criteria level such as level 2 or better and that a percentage of anodes should be tested. An x-ray test might cost approximately $100 per test so it is common for specifications to require 1 in 50 anodes to undergo testing, hence adding $2 to the cost of each anode.

Fig 4.

Specialist Castings have a manufacturing plant in the UK and a state of the art $2m manufacturing facility at Ningbo in China, where both tubular anodes and solid anodes are made. We have anodes stocked in 2 locations in the USA, utilising purpose-made connectors that have been used in over 1 million anodes over the last 35 years (see fig 4 for TA2 and TA5A connectors). We have previously been the only manufacturer exclusively supplying tubular anodes to the Durichlor 51 Anode company. The only tooling that is required to make these connections are 2 torque wrenches (1.2 metres long) that tighten the bolt heads at the end of the connectors, to a pressure of 40lbs (ft/lbs) or 54Nm. These connections can be made in the factory or in the field.

We have 3 XRF chemical analysis machines (in both the UK and China) and our pricing reflects the significant disparity between production costs when comparing foundry production costs in China to those in North America. This chart shows a comparison in sizes between Specialist Castings Anodes and other common anode sizes.

	Specialist Castings / Yuxi Anodes	Die Cast Equivalent
TA2		2.2" x 84" Length
Inside Diameter	35.6mm Nominal	
Outside Diameter	58mm (51mm Min)	56mm Nominal
Weight	20.9KG (20.5KG Min)	23KG Nominal
Length	2134mm (2123mm Min)	2134mm Nominal
Surface Area	0.4Msq	0.37Msq
TA3		2.6" x 84" Length
Inside Diameter	45.7mm Nominal	
Outside Diameter	71.0mm Nominal	69mm Nominal
Weight	28.6KG (28KG Min)	32KG Nominal
Length	2134mm (2123mm Min)	2134mm Nominal
Surface Area	0.5Msq	0.46Msq
TA4		3.8" x 84" Length
Inside Diameter	74.4mm Nominal	
Outside Diameter	96.0mm Nominal	74mm Nominal
Weight	39.2KG (38.5KG Min)	41KG Nominal
Length	2134mm (2123mm Min)	2134mm Nominal
Surface Area	0.6Msq	0.49Msq
TA5		4.8" x 84" Length (Light)
Inside Diameter	99.0mm Nominal	
Outside Diameter	124.0mm Nominal	81mm Nominal
Weight	49.9KG (49.2KG Min)	56KG Nominal
Length	2134mm (2123mm Min)	2134mm Nominal
Surface Area	0.8Msq	0.55Msq
TA5A		4.8" x 84" Length (Heavy)
Inside Diameter	86.4mm Nominal	
Outside Diameter	124.0mm (116mm Min)	94mm Nominal
Weight	79.4KG (79.0KG Min)	79KG Nominal
Length	2134mm (2123mm Min)	2134mm Nominal
Surface Area	0.8Msq	0.63Msq

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