ADAPTIVE ENERGY TECHNICAL BRIEF

JAR 3N Anti-Smutting Agent

The JAR 3N anti-smutting agent non-destructively eliminates surface smutting for nitric acid etch solutions in high-strength modified steels, eliminating the need for a second hydrochloric etching process and reducing the risk of hydrogen embrittlement

Acid Etching of High Strength Steel Components

The use of high-strength, low alloy steels has become common in the aerospace industry for forged components such as landing-gear structures, rocket cases, high-strength bolts and airframe fittings. This type of steel confers the advantages of being very strong for its weight and is corrosion resistant.

Aircraft landing gear made with high-strength steel components

The typical processes for producing and machining high-strength steel components include forging (shaping heated steel with hammers, presses, rolls, etc.) and grinding the forged parts to further refine their shape. These processes can leave burrs (a thin ridge or roughness) or heat burns from the grinding. To create particularly small or complex parts, higher precision methods are needed so an acid etching process may be used. The etching process involves immersing the parts in a nitric acid solution (also known as a nitral bath of nitric acid plus alcohol).

The acid etching process removes a small amount of material from the surface of the metal, providing chemical shaping of the part without affecting the remaining material and surface finish, and without leaving behind heat-affected zones or burrs. The acid also performs surface polishing that prepares the parts for the next steps in the fabrication process.

In addition to its application in the production of intricate parts, acid etching is also used as a non-destructive testing (NDT) method for inspecting high-strength steel components to detect flaws. By removing the surface layer of the steel, the acid allows the grain structure of the material to be examined for any cracks or heat burns.

Challenges: Smutting & Hydrogen Embrittlement

A byproduct of the nitral etching process is smut—a film or coating that collects on the surface of the metal and that must be removed before a part can be used. To remove the smut, typically the part is put through a second acid bath of hydrochloric acid. The hydrochloric acid effectively cleans off the smut, however, if there are microscopic cracks or defects in the part, the hydrogen in the acid will react with the metal.

This reaction can lead to hydrogen embrittlement: over time the steel will become brittle and the part will then be at risk of failure. For mission-critical components such as airplane landing gear, a part failure caused by brittleness in the metal can have disastrous results.

Anti-Smutting Additive Solution

Anti-Smut® 100 (JAR 3N) is an innovative anti-smutting additive that can be mixed into the initial nitric acid bath to prevent the formation of smut during the etching process. It was developed by ISCA, a producer of specialty chemicals, coatings and polymers based in the United Kingdom. Adaptive Energy is the U.S. distributor of JAR 3N.

By preventing smut formation, JAR 3N thus eliminates the need for parts to be put through a second acid bath. The additive has been widely used by aerospace and allied industries around the globe who have found it offers a high level of performance for etch inspection of high-strength, low alloy steel parts. JAR 3N has excellent chemical stability with nitric acid and is easily incorporated into solutions. It does not create a hydrogen evolution reaction during etching, thus preventing the hydrogen embrittlement effect. It has excellent wetting properties and is non-evaporating.

The JAR 3N additive has been used successfully by a number of Adaptive Energy's customers. For example:

- A U.S. airplane manufacturer has used the JAR 3N additive in its production processes for aerospace hazard mitigation systems such as landing gear components. The additive successfully prevents formation of smut during nitral etching, thus eliminating the need for a second acid bath. This saves both time and the cost of maintaining and monitoring a hydrochloric acid etch station.
- A leading U.S. manufacturer and distributor of both standard and custom mobile hydraulic components uses JAR 3N in the production of its steel hydraulic cylinders. By allowing the company to conduct effective nitric acid etch inspection of its parts, JAR 3N is a key element of the quality assurance process, helping to ensure that the hydraulic cylinders will perform in the field over many years of repeated use.

Hydrogen Embrittlement

Hydrogen embrittlement is a general term for a variety of fracture phenomenon caused by the presence of hydrogen in an alloy. Atomic hydrogen, the lightest element, can easily dissolve and migrate within metal, reducing the ductility and load-bearing capacity of the material. This effect can cause cracking and catastrophic failures of components made from the metal. Steel alloys are particularly vulnerable to hydrogen embrittlement, along with titanium alloys and aluminum alloys.

Since the phenomenon was discovered in 1875, hydrogen embrittlement has been a persistent problem for engineers working with structural metal materials in multiple industrial applications, including battleships, aircraft and nuclear reactors. The phenomenon is still not fully understood, but it is known that a hydrochloric acid bath is one cause of embrittlement in metal components. Hydrochloric acid is a clear, colorless liquid composed of hydrogen and chloride; the hydrogen atoms from the acid can ingress into a metal component through microscopic cracks and interact with the atoms of the metal, causing the metal to become brittle.

Forged steel cylinders

Anti-Smut® 100 (JAR 3N) Technical Specifications & Application

Appearance	Clear amber liquid
Color, 20% in water	< 250 Hazen
pH, 20% in water	6.0 – 7.0
Viscosity, 20 C	< 150mPas
Density, 20 C	1037 – 1057 g/cm3
Pour Point	– 0° C
Clear Point	– 0° C
Solubility	Fully soluble in water

Anti-Smut® 100 should be incorporated into the etch solution at ambient temperature. Slight manual agitation of the bath may be required to ensure complete homogeneity. The typical composition for a temper etch solution would be as follows:

- 0.5–5% v/v Nitric Acid
- 3–5% Anti-Smut 100
- Remainder–water

About Adaptive Energy

Adaptive Energy creates customized, non-destructive material evaluation solutions to address mission-critical, time-sensitive testing needs. By combining the latest digital radiography, computed tomography, and ultrasonic imaging technologies with innovative mechanical and robotic assemblies, Adaptive Energy's integrated systems offer rapid deployment, are easy to learn and maintain, and perform reliably under pressure.

Working collaboratively with organizations in the aerospace, automotive, energy, petro-chemical, defense, infrastructure, and materials industries, our experts develop optimized solutions for flaw and crack detection, composite delamination, weld inspection, hardness testing, custom radiation enclosures and overhead gantry systems, and more.

Adaptive Energy is also the exclusive distributor in the U.S. and Canada of FORCE Technology's P-Scan ultrasonic scanners, including the P-Scan Stack with Phased Array, a next generation automated inspection system.

For more information about FORCE Technology and the P-Scan product line visit www.forcetechnology.com, and for details about the P-Scan Stack with Phased Array visit www.p-scan.com.

CONTACT

+1.253.284.0825

Email info@adaptiveenergy.com

Mailing address
Adaptive Energy
P.O. Box 65389
Tacoma, WA 98464

Offices
3011 S. Huson St., Suite B
Tacoma, WA 98409

www.adaptiveenergy.com