
Atlas Tech Note No. 1

Qualitative Sorting Tests for Stainless Steels

These tests are intended for rapid, inexpensive and usually non-destructive and on-site sorting of grades of stainless steel. They are particularly useful for sorting products when, for example, bars of grades 304 and 303 have been accidentally stored together, or grade 304 and 316 sheet offcuts mixed.

Limitations

These tests are extremely useful, but it is important to realise that they have limitations; they cannot sort one heat from another of the same grade, and there is no easy way of sorting certain grades from each other. For instance, it is not possible to readily sort 304 from 321, 316 from 316L or 304 from 304L. The Molybdenum spot test therefore indicates that a piece of steel contains Mo, but does not alone indicate 316 in the absence of other knowledge, the steel could be 316L, 2205 or 904L etc. It is possible to use tests in combination, so an item that is shown to contain Mo, and to be attracted to a magnet is possibly grade 2205, and unlikely to be either 316L or 904L. But is it 444 or 18-2?

Some Other Options

The simple tests described in this Note may assist in grade identification and product sorting. Other, more complex tests can also be carried out; these can involve several chemical reagents, hardness tests or checking response to heat treatment. Proprietary kits can be purchased to carry out some of these tests. In most cases, however, if these simple tests are not sufficient to identify the product it is best to have a full spectrometric analysis carried out by a competent laboratory. Another option is the use of portable analysis equipment, based on spark emission or X-ray fluorescence spectroscopy. This quite sophisticated equipment is used for some PMI (Positive Material Identification) testing where in items are 100% checked for correct composition; this is sometimes a requirement of end users, particularly in the petrochemical or oil and gas project areas.

There are other less common qualitative spot tests available. A manganese spot test is available with specific relevance in sorting "200-series" Cr-Mn-(Ni)-(Cu) austenitic stainless steels from the more usual Cr-Ni "300-series" grades such as 304. The 200-series steels are non-magnetic and otherwise indistinguishable from the 300-series, but do have reduced corrosion resistance and have considerably less value as scrap.

Although this Tech Note is primarily aimed at sorting of stainless steels, some of the tests are also relevant to sorting carbon and low alloy steels. The sulphur spot test is equally relevant to sorting free-machining carbon steels (e.g. 1214 or 12L14) from low-sulphur alternative grades (e.g. M1020, 1045 or 4140).

Prevention

The need for these sorting tests can be reduced if original product identification is retained. Product tags and stickers, and stamped or stencilled Batch/Heat/Grade markings should be retained as much as possible. All product distributed by Atlas Steels has this identification, in line with requirements of our ISO9001 quality system. Atlas also colour code many steel products; details of this coding system including a chart of colours are available for download from the Atlas Steels website.

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Magnetic Response

What Can Be Sorted

Austenitic (both 300-Series and 200-series) stainless steels from other steels. All other steels are attracted to a magnet, including all the ferritic, duplex, martensitic and precipitation hardening stainless steels. The only other non-magnetic steels are the austenitic 13% manganese steels.

Method

Note response, if any, when a permanent magnet is brought close to the steel.

Tips & Traps

Some austenitic grades, particularly 304, are to some degree attracted to a magnet when cold worked, e.g. by bending, forming, drawing or rolling. Stress relieving at cherry-red heat will remove this response due to cold work, but this stress relief may sensitise the steel and should not be performed on an item which is later to be used in a corrosive environment. A full anneal is acceptable, however.

Even although duplex grades have only half the amount of the magnetic ferrite phase compared to fully ferritic grades such as 430, the difference in “feel” of a manual test is unlikely to be enough to enable sorting duplex steels from ferritic, martensitic or precipitation hardening grades.

Austenitic stainless steel castings and welds are also usually slightly magnetic due to a deliberate inclusion of a small percentage of ferrite in the austenitic deposit. The % ferrite can be measured by the amount of magnetic response, and special instruments are available for this.

Safety Precautions

No hazards associated with this test.

Nitric Acid Reaction

What Can Be Sorted

Stainless steels from non-stainless steels.

Method

1. Place a piece of the steel in strong nitric acid (20% to 50%) at room temperature, or a drop of the acid on a cleaned surface of the steel.
2. Test standard samples in the same way, i.e. stainless and non-stainless steel samples.
3. Non-stainless steels will quickly be attacked; a pungent brown fume is produced. Stainless steels are not affected. Compare result with standards.
4. Wash samples thoroughly afterwards.

Tips & Traps

Grease or similar contaminants will prevent the acid contacting the steel surface, so the surfaces should be clean – use detergent or an organic solvent to remove these contaminants. Surface oxide layers such as mill scale will also interfere...these should be filed or ground off, or removed by pickling.

Very lean stainless steels, such as 3CR12 and other 12%Cr grades, are not totally immune from nitric acid attack. They can show some minor reaction, but much less violently than on a carbon or low alloy steel.

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If the product being tested is not stainless steel, there is likely to be significant attack and hence a significant change in appearance. Carry out the test on a surface where any appearance change can be tolerated.

Safety Precautions

Consult the Safety Data Sheet (SDS) for nitric acid and follow directions. Personal protective equipment should be used as directed. Strong nitric acid attacks skin and is very corrosive. Use minimum quantities. Wash off immediately if skin contact occurs. Do not breathe brown fume.

Molybdenum (Mo) Spot Test

What Can Be Sorted

Stainless steels which contain significant Molybdenum from those which do not. The most common use is to sort 304 from 316, but the following grades also contain sufficient Mo to give a positive response to this test – 316, 316L, 317, 317L, 444, 904L, 2205, "6-Mo" grades and all "super duplex" grades (e.g. S32760, S32750, S32550, S32520).

Other similar grades with deliberate Molybdenum additions will also respond.

Method 1

1. Clean the steel surface; use abrasive paper, and if necessary degrease and dry.
2. Use test solution "Decapoli 304/316", "Moly Drop 960" or similar – shake well.
3. Place one drop on the steel of interest, and similar drops on known 304 and 316 samples.
4. Darkening of the test drop in 2 to 4 minutes indicates significant Mo. Compare with indications on the known 304 and 316 samples.
5. Wash or wipe samples clean.

Method 2

Prepare as for Method 1, but the test is an electrochemical one based on kit "1542C" available from

Koslow Scientific Co, USA. Instructions provided with the kit. A very quick and accurate test.

Tips & Traps

Reliable results are only obtained if standard comparison samples and test samples are all the same temperature and freshly cleaned. Avoid very low sample temperatures as this slows reactions. Some Heats of "Mo-free" stainless steels, such as 304, contain enough Mo to give a slight reaction; up to about 0.5% is not unusual. Standard comparison samples must be used.

Safety Precautions

Consult the Safety Data Sheet (SDS) for the product and follow directions. Avoid contact of test solution on skin, and particularly eyes. Wash off immediately if contacted.

Sulphur (S) Spot Test

What Can Be Sorted

Free machining grades of stainless and plain carbon steels, which typically contain about 0.25-0.35% sulphur (e.g. 1214, 12L14, 303, 416, 430F), from non-free machining steels, which typically contain up to 0.03% sulphur.

Ugima 303 contains high sulphur (the same as standard Grade 303) so will give a positive reaction, but Ugima 304 and Ugima 316 have the same low sulphur contents as their standard (non-Ugima) equivalents, so will not give positive reactions.

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Method

1. Clean the steel surface; use abrasive paper, and if necessary degrease. A flat area is preferred.
2. Prepare standard high and low sulphur samples in the same way, e.g. known M1020 and 1214, or 304 and 303.
3. Soak photographic paper in 3% sulphuric acid for about 3 minutes.
4. Press the prepared steel surfaces on the face of the photographic paper for 10 seconds.
5. A dark brown stain indicates significant sulphur. Compare with indications from standard samples.
6. Wash samples thoroughly.

Tips & Traps

Reliable results depend on good contact with the paper, and consistent time of contact. Standard comparison samples must be tested in conjunction with the unknown samples. This test also shows the distribution of sulphur across the tested section, which is useful in some cases.

Safety Precautions

Consult the Safety Data Sheet (SDS) for sulphuric acid and follow directions. Wear personal protective equipment as directed. Avoid contact of acid with skin and eyes. Wash immediately if contacted.

References & Further Information

Atlas Steels Technical Handbook of Stainless Steels

Safety Data Sheets (SDS) for each of the test products.

Limitation of Liability

The information contained in this Atlas Tech Note No. 1 – Qualitative Sorting Tests for Stainless Steels document is not an exhaustive statement of all relevant information. It is a general guide for customers to the products and services available from Atlas Steels and no representation is made or warranty given in relation to this information or the products or processes it describes.