Notes on the differences among non metallic inclusions tested with methods JK, K, M, A, D...

The first thing to know regarding the evaluation of *non metallic inclusions* is that it can be carried out according to different methods presented by the different international Regulator Bodies.

The most important methods for the inclusion level are the following:

- **UNI 3244:** "Microscopic examination of ferrous materials. Rating of non-metallic inclusions in steels with reference pictures".
- **DIN 50602**: "Microscopic examination of special steels using standard diagrams to assess the content of non-metallic inclusions"
- **ISO 4967: "**Steel - Determination of content of non-metallic inclusions -- Micrographic method using standard diagrams"
- **ASTM E45-13:** "Standard Test Methods for Determining the Inclusion Content of Steel"

Here below is a schematic description of these test procedures, allowing a better understanding of the subject.

Let's see which are the kind of inclusions listed:

The non metallic inclusions, according to their morphology, are of 4 different types:

1. sulphides, they show a long and narrow shape and a color aiming to light grey;
2. oxides fragmented and aligned, referable to alumina;
3. oxides with long and narrow shape like silicates, with a polyhedric form and sharpened corners;
4. oxides with globular shape, homogeneously dispersed in the structure.

Why it is important to evaluate micro purity of a steel?

The **non metallic inclusions** can cause a damage of the matrix that is mainly depending on their shape and mechanical characteristics, besides their diffusion. The most dangerous ones are inclusions with a crystal shape with sharpened corners, because they are the hardest ones and cause greater distortions of the metallic matrix (for example, oxides like alumina or silicates); this kind of inclusions can lead to breakings during the thermal treatment or shorten the life of a component which is subject to fatigue.

In other cases, inclusions can be used, within a certain limit of course, to improve the workability on the machine tools (for example long and narrow sulphides).

The norms UNI 3244, DIN 50602 and ISO 4967 prescribe that the tests to evaluate the inclusion level is done on metallographic sections examined under the metallographic microscope for an eye comparison with model images.

The record of the non metallic inclusions can be carried out according to one of the following methods:

- **method M**, that is according to maximum degree, it allows to evaluate the maximum degree for each inclusion which is observed;
- **method K**, that is according to a minimum degree pre-arranged, making summation indexes (for example K4); in this case the evaluation of inclusions is made by starting from an arranged minimum degree, and the result is expressed in relation with the total surface of the analyzed section converted to a trial surface of 1000 mm^2. The calculation is done by multiplying the summation of inclusions by the relative seriousness index, and then dividing by the area of the sample, and finally the summation is multiplied by 1000;
- **method JK** (Jernkontoret): it provides the expression of the micro pureness as the average of the grade of inclusions found on the surface. The calculation is made by multiplying the inclusions found by the relative degree and then dividing for the total number of inclusions noticed.

Also ASTM E45 standard provides that the definition of the inclusions is made on the basis of metallographic samples subject to examination under the microscope, comparing by eye the observed micrography to the model images provided by the standards.

The main methods to record the inclusions according to the American standard are the following:

- **method A** (worst field): it allows to evaluate the maximum index for each inclusion found according to the classification (A sulphides, B alumina, C silicates and D globular oxides) and the dimension (fine series or thick series).
- **method D** (content of small inclusions): method used for evaluating all inclusions found on the metallographic section, related to tan area of 160 mm^2, according to morphology, dimension and distribution.

Whatever steel is being used, according to the standard for evaluating the conformity for the acceptance of the material, the most suitable method can be chosen according to the situation, in order to evaluate the non metallic inclusions**.**