STAINLESS STEEL FOR THE NEW PS VACUUM CHAMBER:

STATUS REPORT

Stainless steel strips for the new PS Vacuum Chambers have now been delivered. This note gives a summary of all chemical, physical and geometrical characteristics measured so far.

A) Stainless steel strips (AISI 316LN) for the standard chamber

200 strips (5500 x 200 x 2 MM) were ordered from BOEHLER (A) on April 16th, 1985 (PS/ML/Spec 84-18, order R/788.672/PS/ML)

Due to problems during manufacture, the steel has been made in two batches (i.e. with 2 mother melts). In order to meet UHV cleanliness standards (inclusion contents), both lingots were ESR (ELECTRO SLAG REFINED) remelted.

1) Chemical composition (%):

1st batch:

<table>
<thead>
<tr>
<th>Element</th>
<th>1st batch</th>
<th>2nd batch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.016</td>
<td>0.017</td>
</tr>
<tr>
<td>Chromium</td>
<td>17.3</td>
<td>17.3</td>
</tr>
<tr>
<td>Iron</td>
<td>rest</td>
<td>rest</td>
</tr>
<tr>
<td>Mg</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Mo</td>
<td>2.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Nickel</td>
<td>13.6</td>
<td>13.4</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.12</td>
<td>0.14</td>
</tr>
<tr>
<td>Ph</td>
<td>0.028</td>
<td>0.029</td>
</tr>
<tr>
<td>S</td>
<td>0.025</td>
<td>0.015</td>
</tr>
<tr>
<td>Si</td>
<td>0.8</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Both steels are almost chemically identical and well within CERN spec.

2) Inclusion content (cleanliness) and surface finish

Both batches have been found to be very clean, after final cold rolling: class 1 along ASTM E45/69 standard, Jernkontoret Method. This is well within CERN specification no. 154. Aluminium nitrides found after the ESR remelt of the first batch vanished after the numerous subsequent rollings.

The surface finish, generally within CERN spec., was somewhat altered by fine grinding on about half of the first batch, in order to eliminate small defects (scales) resulting from the cold rolling.

3) Electrical characteristics and thickness

The relative magnetic permeability was not measured. However considerable experience with that grade of steel gives confidence in \( \mu \)'s less than 1.004.
The thickness of all the strips was measured with an ultra sonic gauge on more than 2'400 points. No systematic deviation was found. On single strips the standard deviation has never exceeded 5 microns, and the average thickness is:

$$2.008 \text{ MM} \pm 0.015$$ (standard deviation)

with minimum and maximum:

$$1.97 \text{ , } 2.03 \text{ MM}$$

That is, all thicknesses are within $\pm 1.5\%$.

The electrical resistivity, measured on nine samples spread on each delivered batch was:

1st batch : $\rho = 80.36 \mu \Omega \text{ cm} \pm 0.28$ (standard deviation)

2nd batch : $\rho = 80.5 \pm 0.15$

minimum value 79.8, maximum 80.9

This is remarkable given the fact that we had 2 melts! (previous measurements on 316 LN from various sources had shown a much larger scatter).

Finally, the relevant criterium of $\frac{\rho}{\varepsilon}$ (thickness) $\frac{\text{resistivity}}{(MM/\mu \Omega \text{ cm})}$

is on the average:

$$\text{(MIN)} \quad 0.0247 < \frac{\rho}{\varepsilon} < 0.0251 \quad \text{(MAX)}$$

$$(-1.2\%) \quad (+0.4\%)$$

which is well within our recommended spec. of

$$\frac{\rho}{\varepsilon} = 0.025 \pm 4\%$$

(see PS/PSR/Min.85-6)

B) URANUS 625 strips for the standard enlarged chamber

45 strips (5500 x 500 x 2.4 MM) were ordered from USINOR (F) on May 22nd, 1985, (PS/ML/Spec. 84-18 - R/A 000367/PS/ML). The steel was vacuum melted by Creusot Loire.

1) Chemical composition (%):

<table>
<thead>
<tr>
<th>Carbon</th>
<th>Chromium</th>
<th>Iron</th>
<th>Mg</th>
<th>Mo</th>
<th>Nickel</th>
<th>Si</th>
<th>Ti</th>
<th>Nb</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.015</td>
<td>20.4</td>
<td>4.6</td>
<td>0.2</td>
<td>10.6</td>
<td>60</td>
<td>0.36</td>
<td>0.3</td>
<td>4.0</td>
</tr>
</tbody>
</table>

(cobalt < 0.04)
2) Inclusion content (cleanliness) and surface finish

Inclusions were counted following the same Jernkontoret Method. The steel was found to be exceptionally clean for a one melt (under Vacuum) steel. It is well within CERN spec. (class 1.5 max.). The finish was up to expectation, the only defect being wiggles on some strips which occurred in the last flattening operation. These should disappear on chamber forming.

3) Electrical characteristics and thickness

The relative permeability was measured on 8 samples under an excitation of 1000 Oe. It was found to be less than 1,002.

The thickness of all 45 strips was measured as above (more than 2000 points). Systematic deviations were found both transversely and longitudinally: strips are thinner on the edges than in the middle (Δmax. < 0.1 MM), strips taken on the rolls extremities being thicker.

Eight strips (NR : 42, 37, 28, 25, 24, 23, 14, 7) of lowest and highest average thicknesses were removed from the batch necessary for the manufacture of the standard enlarged chambers. These will be used on special chambers which will anyway require a special eddy current correction.

The average thickness on the remaining 37 strips is:

2.432 MM ± 0.021 (standard deviation)

with minimum and maximum:

2.37 , 2.47 MM

The electrical resistivity, measured on 20 samples spread on the whole batch was:

\( \rho = 125,15 \, \mu \Omega \, \text{cm} \pm 0.53 \) (standard deviation)

with a minimum value of 124.5 and a maximum of 125.8

Finally, the relevant criterium of \( \frac{e}{\rho} \) (resistivity) is, on the average:

\[
(\text{MIN}) \ 0.01884 < 0.0194 < 0.01986 \ (\text{MAX}) \\
(-2.88\%) \ \ (+2.3\%)
\]

which is well within our recommended spec. of

\( \frac{e}{\rho} = 0.019 \pm 4 \% \ (\text{mm/}\mu \Omega \ \text{cm}) \)
C) Conclusion

In all respects, the steel quality for the new PS Vacuum Chamber is well within specifications. Reality is probably even better than indicated, some dispersion resulting from measurement errors. More measurements of electrical resistivity will be performed, particularly after Vacuum firing of the samples (although we know from previous experience that there should be no change).

Let us hope that Chamber manufacturing will reach the same quality level!

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