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HIGH VACUUM CHAMBERS FOR HIGH ENERGY PHYSICS.

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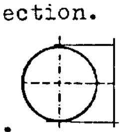
RESUME. The presented paper reports the design, manufacture, finishing, cleaning and testing systems used for production of stainless-steel welded high vacuum chamber pipes, circular and non circular sections, drawn in special sections, used for high energy physics accelerating machines, linear and circular, for dipoles, quadrupoles, sextupoles, etc., for special heat exchangers, for liquid gases handling, transport, etc.

We manufacture high vacuum chamber pipes for high energy accelerating machines and particularly for S.P.S. Super Proton Synchrotron Accelerator Main Ring Vacuum System, C.E.R.N. Geneve, for Proton - Antiproton Collider operations, with working pressure 1×10^{-9} mbr.

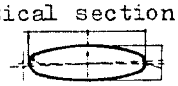
The S.P.S. Ring Magnet Module with normal period length of 64 m, is repeated 106 times, for a total length of about 7 km.
The vacuum performance of S.P.S. vacuum system is reported in the paper [1].
In the same paper information is given about the Titanium Sublimation Vacuum Pumps for wich We manufactured the jackets, the traps, etc., also in stainless-steel.
Different sections were supplied to other users as components of colliding beam machines and accelerators, for synchrotron light surces, for special heat- exchangers for handling and transport of liquid gases, etc.

We manufacture special high vacuum chamber pipes in stainless-steel, for over ten years; We list some of the special high vacuum chamber pipes sections manufactured till now:

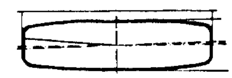
1- Our Drawing D/1557. Circular section.
Diam. 86, thick. 1,5,
length 4.000 mm.
Stainless-steel AISI 316 L N.
QD. Quadrupole defocusing. SPS.



2- Our Drawing D/1405. Elliptical section.
Diam. 156 x 46,6, thick. 2,
length 4.000 mm.
Two curves R = 13, two R = 235 mm.
Neutral perimeter 338,5 mm.
Stainless-steel AISI 316 L N.
QF. Quadrupole focusing. SPS.

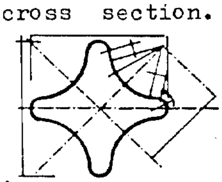


3- Our Drawing D/1785. Semirectangular sect.
Sides 156 x 42,7, thick. 2,
length 4.000 mm.
Four curves R = 10,
two R = 76, two R = 750.
Neutral perimeter 359,6 mm.
Stainless-steel AISI 316 L N.
MBA. Main bending magnet type A. SPS.

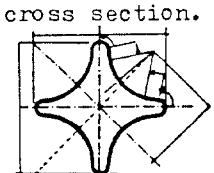


4- Our Drawing D/1555. Semirectangular sect.
Sides 132 x 56,5, thick. 1,6,
length 4.000 mm.
Four curves R = 8,
two R = 66, two R = 500 mm.
Neutral perimeter 335,7 mm.
Stainless-steel AISI 316 L N.
MBB. Main bending magnet type B. SPS.

5- Our Drawing D/1603. Large cross section.
Sides 166 x 166, thick. 2,
length 4.000 mm.
Four curves R = 12,
four R = 63,5 mm.
Neutral perimeter 508 mm.
Stainless-steel AISI 316 L N.
QWL. Quadrupole low biter insertion. SPS.



6- Our Drawing D/1601. Narrow cross section.
Sides 166 x 166, thick. 2,
length 4.000 mm.
Four curves R = 7,6,
four R = 57 mm.
Neutral perimeter 508 mm.
Stainless-steel AISI 316 L N.
QMB. Quadrupole low biter insertion. SPS.



The high vacuum chamber pipes are manufactured from cold rolled sheets, after checking surface state, finish, thickness, tollerances, etc. We stopped to use seamless pipes and rolled coils, for differences noted in surface state, finish, thickness, tollerances, etc.

The sheets are cut in stripes with width equivalent to the circumference or the neutral perimeter and the nominal length plus about 600 mm or more for calibration and drawing operations, depending upon the section to be obteined. Some tollerances have to be calculated, based on production experience, material thickness, material composition, drawing tool form, surfaces, hardness, lubrication layer, finish, material elasticity, elongation.

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The sheets stripes are rolled and completely welded by T.I.G., with Argon Gas protection on both sides, weld penetration 100%, weld bead outside flushed with positive tollerance of less than 0,2 mm max. It is essential for vacuum, the welding speed and the welding regulation, in order to have a rather small and regular weld ribbon bead, without leaks or inclusions of unwanted material.

It is fundamental that the welding operations are executed in a rather clean room, without air turbolence, by professional people who can control by sight the welding process. A cooling of the weld ribbon bead is best done by using cold gas or different systems.

After welding the high vacuum chamber pipes are heat treated in oven to about 1.050°C, taking special care of the heating and cooling speed, temperature, vacuum, inert gas atmosphere, etc. Such treatment is essential to release internal tensions coming from welding operations and to restore the austenitic structure in the welding area. It determines the magnetic permeability of the material, its elasticity, its resistance to metal fatigue, pulsations, vacuum thightness, magnetic field quality, magnet efficency, luminosity, etc.

The high vacuum chamber pipes are then decapped, pickled, passivated, lubricated by a special mixture of inorganic components in order to avoid pollution of surfaces, expecially inside the pipes, and easy rimotion by washing.

Calibration and drawing of high vacuum chamber pipes are done at room temperature. Friction is very high between the high vacuum chamber pipe walls and the tool surfaces; it is necessary to use a well distributed and efficent layer of lubricant. The weld ribbon bead has to be constant in thickness. The drawing speed, the drawing force and connected parameters have to be controlled; also surface temperature control is essential.

After calibration the high vacuum chamber pipes are retreated in oven and again decapped, pickled, passivated, lubricated and finally drawn to its required form.

When special profiles are needed such as cruciform or with curves wich are narrow in comparison to the material thickness, the drawing operation have to be repeated again with heat treatment, etc., as above described. The drawing operation is sensitive and must be carried out by experienced people.

The high vacuum chamber pipes, after final drawing, are cutted to the nominal length. This operation has to be followed with care in order to mantain the formed shape and avoid "blossoming" of the cutted ends.

Then the high vacuum chamber pipes are decapped, pickled, passivated and finally washed and cleaned according to accepted vacuum Standards. The vacuum test is carried out at the limit pressure of 1×10^{-9} mbr, and the leak rate in Helium below 1×10^{-11} mbr l/s.

The high vacuum chamber pipes are sealed with polythene covers at both ends, and marked according user order with progress number for identification, dimesións, material quality.

The high vacuum chamber pipes, specially if operating in a magnetic field, are normally required in stainless-steel with low magnetic permeability, regular austenitic structure, with few globular inclusions.

The high vacuum chamber pipes built in stainless-steel AISI 316 L N, expecially in non circular sections, compared with the same in AISI 316 L, for the different elastic module, AISI 316 L N = 33 Kg/mm^2 against AISI 316 L = 21 Kg/mm^2 make possible reduction of pipe wall thickness and consequent reduction of magnets dimensions installation costs and electric power working costs. In particular the use of high vacuum chamber pipes in stainless-steel AISI 316 L N gives very high magnetic field quality, electric power save, better magnet efficency, luminosity, etc.

We stopped the production of short high vacuum chamber pipes of about 500 - 1.000 mm length manufactured by welding two pre - formed half - pipe sections, because after the double welding the internal tensions in the metal structure are too high, it is difficult the heat treatment in oven at about 1.050°C while mantaining the shape section of the pipe and it is difficult to drawn the double welded pipe with two weld ribbon inside. The lack of heat treatment introduces high possibility of metal fatigue in the metal structure and presents noticeable areas with different austenitic structure and magnetic permeability degree, specially in the double welding zone besides different elastic module for each of single weld; as consequence there are probabilities of vacuum leakages with following working stop, for all the system, with time, experience and economic losses. The above events are rather common in different institutions depending on reduced experience, supposed money savings, etc.

We have experience and We know the system for manufacturing high vacuum chamber pipes; We are continusly trying to improve Our knowledge. You use Our experience and it will be ceaper.

The use of non circular section pipes, as above, for heat - exchangers, gives better efficency, avoiding the formation, inside the pipe, of constant temperature layers, improving mixing for different pressure values. Moreover the non circular section pipes present larger surfaces and better geometrical area occupation.

For liquid gases handling and transport, the above circular and non circular section pipes are more resistant to temperature variations, more elastic and better suited for field and tankers installation and operation.

Aknowledgement.

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[1] B. Angerth, R.B. Flockart, G. Kouba, H. Wahl.
"Performanc of S.P.S. Ring Vacuum System for colliding beam operations".
Presented to the "1983 Particle Accelerator Conference".
Santa Fe, New Mexico, U.S.A. March 21-23,1983.

Some manufactured sections.