

This reference material is a low-alloy steel conforming ASTM A 242 specifications, presented in the form of discs with approximately 35 mm in diameter and 15 mm in thickness. This material was certified by the consensus of results from two networks of expert laboratories using different methodologies and techniques.

| Property | Certified Value (%) | Expanded Uncertainty (%) |
|-----------------|---------------------|--------------------------|
| Manganese (Mn) | 0,842 | 0,006 |
| Chromium (Cr) | 0,611 | 0,006 |
| Silicon (Si) | 0,281 | 0,003 |
| Copper (Cu) | 0,270 | 0,004 |
| Carbon (C) | 0,107 | 0,002 |
| Aluminum (Al) | 0,046 | 0,002 |
| Nickel (Ni) | 0,018 | 0,001 |
| Phosphorus (P) | 0,016 | 0,001 |
| Nitrogen (N) | 0,0092 | 0,0003 |
| Niobium (Nb) | 0,0083 | 0,0009 |
| Sulfur (S) | 0,0049 | 0,0005 |
| Cobalt (Co) | 0,0044 | 0,0004 |
| Vanadium (V) | 0,0029 | 0,0006 |
| Arsenic (As) | 0,0020 | 0,0003 |
| Molybdenum (Mo) | 0,0018 | 0,0007 |
| Tin (Sn) | 0,0018 | 0,0006 |
| Titanium (Ti) | 0,0015 | 0,0002 |

| Property | Reference Value (%) | Expanded Uncertainty (%) |
|--------------|---------------------|--------------------------|
| Boron (B) | 0,0004 | 0,0002 |
| Calcium (Ca) | 0,0025 | 0,0005 |

Single batch

Valid until: 02/2034

The certified values and uncertainties are assured by the validity period, considering that the material is handled and stored in accordance with the given instructions, except in case of damage or contamination. IPT will monitor periodically the properties of this reference material during its validity period, and any observed significant change will be reported to the registered user.

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The elemental chemical characterization of this material was conducted in two interlaboratory programs with the participation of expert laboratories, employing different techniques, including Spark Optical Emission Spectrometry (Spark-OES), Wavelength Dispersive X-ray Fluorescence (WD-XRF), Atomic Absorption Spectroscopy (AAS), Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), Inductively Coupled Plasma Mass Spectrometry (ICP-MS), as well as the determination of carbon and sulfur by direct combustion and nitrogen by fusion under inert gas.

Uncertainties

The expanded uncertainties of the certified values were estimated by combining the uncertainties of characterization, estimated from the results obtained in the interlaboratory programs, with estimates of uncertainties of homogeneity and stability obtained from experimental studies conducted at IPT. The expanded uncertainties of the reference values were estimated based on the uncertainties of characterization, but not including other contributions of uncertainty.

Certified values and reference values

The certified values represent the best estimates of the true values, and their uncertainties include contributions from measurement, stability, and homogeneity, making them suitable for calibration, precision and accuracy verification, method development, and demonstrating result traceability. Reference values represent the best estimates of the true values, but their uncertainties do not include contributions from homogeneity and stability.

Traceability

The certified values of the properties of this material were obtained through determinations carried out at IPT and collaborating laboratories, using one or more methodologies for each property studied. The methodologies were verified using reference materials and standards with certified values traceable to the International System of Units (SI), through NIST and other qualified producers. The measuring instruments were calibrated with standards traceable to the SI through Inmetro and the Brazilian Calibration Network (RBC).

Minimum Sample Mass

The material is compatible with the experimental parameters of direct instrumental techniques such as WD-XRF and Spark-OES, provided that the conditions established in recognized methods or in the latest technical standards are respected. In the case of chip extraction for analyses requiring dissolution, such as AAS, ICP-OES, ICP-MS, etc., it is recommended to use sample mass greater than 100 mg.

Handling, storage and safety

Handling: The discs should have their surface properly prepared before determinations by Spark-OES and WD-XRF. Follow the specific guidelines of your measurement method or technical standard. After surface treatment, keep the piece in a clean and dry place, and avoid touching the analysis surface. For chip extraction, use methods that do not cause metallic contamination, typically generated by the action of inadequate tools or processes.

Storage: This material should be stored in its original packaging at room temperature, in a dry place, ideally less than 60% RH.

Safety: Relevant information is presented in the Safety Data Sheet (SDS), available for search from the following page: <https://www.iptlrm.com/>

Technical Notes

The original raw material of this material underwent a homogeneity assessment by Spark-OES. At the time of preparation of this batch, a new homogeneity study was conducted using WD-XRF, C/S Analyzer, ICP-OES, and ICP-MS, which confirmed the initial homogeneity.

Additional Information

The raw material for the preparation of this reference material was produced by Companhia Siderúrgica Paulista.

Collaborating Laboratories

This material was certified using results obtained from two interlaboratory programs, in the first program the following organizations participated: IPT, Aço Minas Gerais, Aços Villares, Cobrasma, Acesita, Companhia Siderúrgica Nacional, Companhia Siderúrgica Paulista and Eletrometal. The second program had collaboration from the following organizations: Gerdau, IPT, Laboratorio Tecnológico del Uruguay, Laboratórios Tork, MIB Engenharia, Muriaço do Brasil, ProaqT Empreendimentos Tecnológicos, Qalytest, Riolab, Senai-SC, Stihl, Teamlab, Tenaris-Confab, Uniforja, Usiminas and Villares Metals.

Methodologies Employed in the Certification of CRM IPT 500A

| Element | Analytical Techniques | Element | Analytical Techniques |
|-----------|--|-----------|---|
| Al | AAS, ICP-OES, UV-Visible (Eriochrome Cyanine), Spark-OES, WD-XRF | N | Spark-OES, Fusion under inert gas (Thermal conductivity) |
| As | UV-Visible (Silver Diethyldithiocarbamate), ICP-OES, AAS, Spark-OES, WD-XRF, ICP-MS | Nb | ICP-OES, UV-Visible (Sulfochlorophenol-S), Spark-OES, WD-XRF |
| B | Spark-OES, ICP-OES | Ni | AAS, ICP-OES, Gravimetry (Dimethylglyoxime), Spark-OES, WD-XRF, ICP-MS |
| C | Spark-OES, Direct Combustion (Infrared) | P | Spark-OES, WD-XRF, ICP-OES |
| Ca | Spark-OES, ICP-OES | S | Direct Combustion (Infrared), Spark-OES, WD-XRF |
| Co | AAS, ICP-OES, Spark-OES, WD-XRF | Si | Gravimetry (Dehydration with perchloric acid), Spark-OES, WD-XRF, ICP-OES |
| Cr | AAS, Titrimetry (Iron (II) Sulfate), (Ammoniacal Iron (II) - Permanganate), UV-Visible (Perchloric Acid), Spark-OES, WD-XRF, ICP-OES | Sn | AAS, ICP-OES, Spark-OES, WD-XRF, ICP-MS |
| Cu | ICP-OES, AAS, Titrimetry (Iodometry), Spark-OES, WD-XRF | Ti | AAS, ICP-OES, Spark-OES, WD-XRF |
| Mn | UV-Visible (Periodate), (Persulfate), AAS, Titrimetry (Persulfate-Arsenite), Spark-OES, WD-XRF, ICP-OES | V | AAS, ICP-OES, Spark-OES, WD-XRF |
| Mo | UV-Visible (Thiocyanate – Tin (II) Chloride - Butyl Acetate), (Thiocyanate – Tin (II) Chloride), AAS, Spark-OES, WD-XRF, ICP-OES, ICP-MS | W | Spark-OES, WD-XRF, ICP-MS |

Legend:

| | |
|-----------|--|
| AAS | Atomic Absorption Spectrometry |
| ICP-OES | Inductively Coupled Plasma Optical Emission Spectrometry |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometry |
| Spark-OES | Spark Optical Emission Spectrometry |
| UV-Vis | UV-Visible Spectroscopy |
| WD-XRF | Wavelength Dispersive X-ray Fluorescence Spectrometry |

Informative Values

Informative values – Chemical Composition

The chemical composition of some elements could not be certified according to the criteria adopted by IPT, and thus cannot be used for calibration, precision and accuracy verification, method development, and demonstration of result traceability. However, they can still be useful as technical information for some users.

| Property | Informative Values | | Notes |
|----------------|--------------------|---------------------------|---|
| | Robust Mean | Robust Standard Deviation | |
| Antimony (Sb) | 0,0033% | 0,0020% | 5 labs (2 Spark-OES, 2 WD-XRF, 1 ICP-OES) |
| Cerium (Ce) | 0,0003% | - | ICP-OES in 1 lab |
| Lead (Pb) | 0,0029% | 0,0025% | 5 labs (4 Spark-OES + 1 ICP-MS) |
| Magnesium (Mg) | 0,00022% | 0,00018% | 2 labs (1 Spark-OES, 1 ICP-MS) |
| Oxygen (O) | 0,0082% | 0,0022% | 2 labs (Fusion under inert gas) |
| Tungsten (W) | 0,0092% | 0,0128% | 6 labs (ICP-MS, 3 Spark-OES, 2 WD-XRF) |
| Zirconium (Zr) | 0,0018% | 0,0007% | 3 labs Spark-OES |

Informative Values - Metallography

Portions of this reference material had their metallographic characteristics studied in the 6th Round of the Steel Proficiency Program - IPT/LRM. Results from 20 laboratories indicated the grain size (ASTM E112) as G = 8 (median). Results from 14 laboratories indicated proportions of 84% ferrite and 16% pearlite (medians). These values are informative and are not suitable for metrological uses such as calibrations.

The latest versions of the IPT's Reference Material Certificates are available for download at the following pages: <https://www.iptlr.com/> and <https://www.ipt.br/nmr.htm>.