SHIMADZU

Excellence in Science

Optical Emission Spectrometer

PDA Series

PDA Series

Combines the best of each
Shimadzu Optical Emission Spectrometer

For many years, Shimadzu has supplied the world with the Optical Emission Spectrometers
that are indispensable for the quality control of metals.

Combining the best of all these instruments, Shimadzu has launched in 2004 the PDA-7000, the
high-end model, that satisfies every customer's demand in various metals applications. Shimadzu now
presents the PDA-5500S, the entry model of ferrous and aluminum application.

In both models Shimadzu's unique time-resolution PDA photometry is installed as standard feature so
as to provide powerful backup for quality control analysis.

PDA-7000

1935
Created Japan's first spectroscope.

1953
Created the direct-reading spectrometer. An atmospheric-type
spectrometer supplied to the non-ferrous metals industry.

1960
Created the vacuum spectrometer, permitting analysis of vacuum UV wavelengths,
including C, P, S, and B.

1974
Developed and patented speciation analysis of aluminum in steel.
Sold first fully automated analysis instrument.

1978
Developed the pulse distribution analysis (PDA) method,
which received the Okochi Memorial Prize.

1988
Applied new optics technology to achieve measurements in the extreme
ultraviolet region (H, O, N) with a glow discharge spectrometer.

1989
Achieved molten metal control measurements of nitrogen (N) in cast
iron using the OES-5014 optical emission spectrometer.

1999
Developed new technologies for the measurement of inclusions in steel.

2004
PDA-7000 Fe base launched

2009
PDA-5500S Fe base launched

2011
PDA-5500S Al base launched

Features of the PDA Series

Shimadzu's unique PDA photometry is installed as standard to offer a variety of benefits for various analyses.

▌ PDA Photometry (Pulse Distribution Analysis Photometry)

Unlike conventional photometry that simply integrates the photocurrent obtained from discharges over a fixed time, the PDA method integrates the photocurrent obtained from each discharge pulse and analyzes each integral value as having an individual significance. The optimal processing is then used to determine the percentage content. PDA permits speciation analysis and a variety of data processing not possible with previous methods, which significantly increases the analysis accuracy for many elements.

▌ Time-resolution Analysis (Patented)

The discharge conditions to obtain the optimal measurement sensitivity differ for each spectral line. The diagram at the right shows the current waveform for typical discharge conditions. Some elements exhibit sensitivity in Area A, others in Area B. Analyzing the elements separately in the individual areas dramatically enhances the sensitivity for trace elements.
The table below compares the Background Equivalent Concentration (BEC) values for a conventional method and the PDA Series. The lower the BEC value, the higher the sensitivity for trace elements.

Element	C	P	S	B
Conventional method(ppm)	160	150	100	80
PDA Series(ppm)	80	75	50	40

Time-resolution Photometry
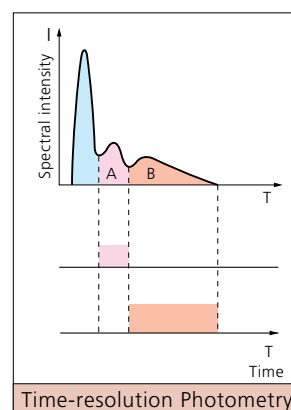
▌ Shorter Analysis Times (just over 10 seconds per analysis)

Combined discharge and PDA time-resolution photometry obtain results in just over ten seconds per analysis.

▌ Data is Controllable for each Discharge, Allowing Photometric Values for Abnormal Discharge Pulses to be Eliminated for Enhanced Accuracy

Conventional photometry determines the overall integral value of the light intensities. However, the PDA Series determines the frequency distribution of the light intensities and then conducts statistical processing, thereby achieving measurements that are unaffected by light intensities from abnormal discharges.

▌ Enhanced Accuracy for Insoluble Elements that Readily Form Inclusions (Patented)

Achieves two or three times the reproducibility of conventional Shimadzu methods. The table at the right compares reproducibility values for a conventional method and the PDA Series for elements that readily form inclusions.

Element		Total Al	S	Pb	B	Ca
Content (%)		0.037	0.022	0.005	0.0035	0.002
Reproducibility s (%)	Conventional method	0.0025	0.0010	0.0010	0.00027	0.00045
	PDA Series	0.00045	0.0004	0.0002	0.00005	0.0001

Reduced Effects of Sample Defects (cracks, pinholes) on Analysis Values (Patented)
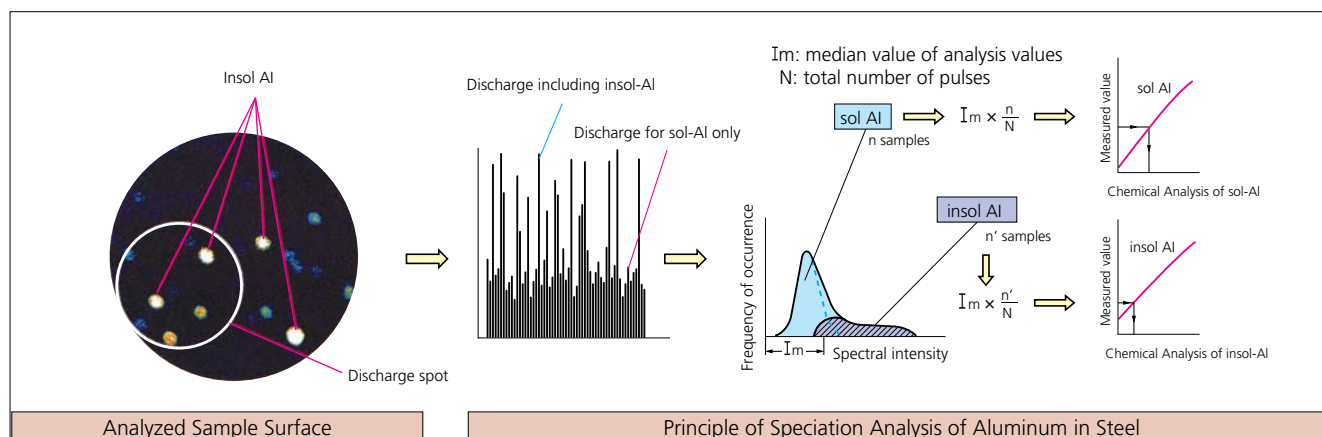
The internal standard monitoring method is applied to each discharge pulse to monitor the light intensity for internal standard elements. If this value lies within the specified range, the light intensities obtained for the measured elements are selected.
To enhance reproducibility, statistical processing is used to eliminate the data obtained when the spark is applied to a defect resulting from sampling.

I_M: median value of internal standard elements I_H, I_L: discriminator levels

Monitoring with Internal Standards
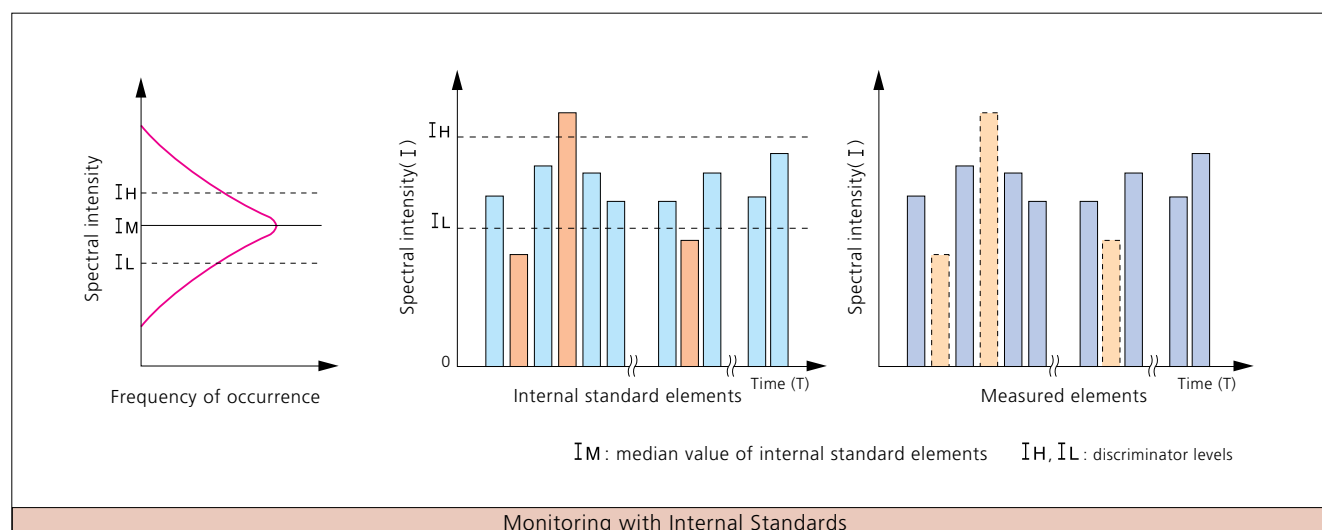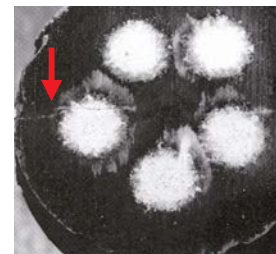
Acid-soluble Speciation Analysis (Quantitation of Acid-soluble Aluminum)

Statistical processing based on the differences in light intensity between acid-soluble aluminum (sol-Al) and acid-insoluble aluminum (insol-Al) allows quantitation of acid-soluble aluminum in just 1 seconds.

I_m: median value of analysis values
N: total number of pulses

sol Al $\Rightarrow$ $I_m \times \dfrac{n}{N}$

insol Al

$I_m \times \dfrac{n'}{N}$

Analyzed Sample Surface   **Principle of Speciation Analysis of Aluminum in Steel**

PDA Series
Optical Emission Spectrometer   5

Features of the PDA Series

▌ Sensitive Analysis of Trace Elements in Steel

The establishment of manufacturing technologies for high-purity iron demands process control at lower trace levels of elements, including C, P, and S.

The PDA-7000 meets these needs by permitting quick and easy ppm-level analysis by time-resolution PDA photometry.

▌ High-sensitivity Analysis of Nitrogen in Steel (PDA-7000 only)

Due to the significant effects of nitrogen on the mechanical properties of steel, the rapid measurement of nitrogen during the manufacturing process is highly desirable.
The PDA-7000 has recently been developed to replace gas analyzers for in-furnace analysis. It achieves a lower detectable

limit of 5 ppm. This instrument reduces sampling operations and shortens analysis times. Additionally, it eliminates sample defects and enhances yields through its ability to control nitrogen in cast iron.

▌ Vacuum Monochromator

The monochromator must be held in a vacuum or in a gas-replacement atmosphere to avoid effects due to the absorption of spectral lines such as C, P, S, B, and N by atmospheric oxygen.

Shimadzu adopts a vacuum monochromator that is resistant to the effects of temperature fluctuations. It is installed in a temperature-controlled monochromator chamber to achieve extremely stable measurements.

▌ Electrode Cleaning Extends Electrode Life approx. 10 Times

Electrode life is increased by approximately ten times by adopting brushing for electrode regeneration in addition to conventional reversed discharge. Naturally, the convenient reversed discharge is also provided as standard.
To enhance long-term stability, the optional automatic

electrode-cleaning unit (page 10, PDA-7000 only) can be selected to keep the counter electrode clean by automatically brushing away adhering sample deposits. The attached automatic sample retainer mechanism allows everyone to set samples under identical conditions.

▌ Elimination of Contamination Effects

Replaceable units in the new spark stand eliminate to the maximum degree effects from high-content sample analysis during trace-element analysis.

This effectively eliminates effects from the analysis of aluminum alloys when high-purity aluminum is analyzed, for example.

▌ Reduced Effects of Sample Defects (cracks, pinholes) on Analysis Values (Patented)

The structure and materials of the conventional spark stand have been upgraded to considerably enhance analysis accuracy for high-concentration elements (stainless steel and aluminum alloy). It accepts large sample plates, offers greater ease of handling, and enhances durability.
Further, selecting the optional stand water-cooling kit (see page 12) restricts the spark stand temperature rise due to electrical discharge during continuous analysis, thereby enhancing the stability of the measured values.

Spark Stand

▌ New Chassis Case Design offers Superb Environmental Resistance

The newly designed chassis case enhances environmental resistance.
The monochromator is made of materials resistant to the effects of temperature fluctuations and is installed in a constant-temperature chamber.

The popular compact design is retained. The chassis case can be mounted against the wall to save space. The functional design allows maintenance access from the front.
The chassis case design offers greater freedom in analysis laboratory layout.

▌ Select Optimal Discharge Conditions to Suit Analysis Range and Elements

Several separate discharge types are available for each analyzed element: high-energy discharge, spark discharge for excellent reproducibility, and arc-like spark discharge for high sensitivity. A combination of these can also be selected to set the optimal discharge conditions.

Used with time-resolution photometry, these settings achieve high analysis accuracy.
The addition of the optional small-sample analysis kit (page 11) permits measurements on 0.01 mm-thick samples and small-diameter samples.

▌ User-friendly Software

The software was designed for process analysis, with due consideration of the situation at sites where metals analysis is conducted in Japan. After the instrument is started, only one action is required to enable measurement and allow simple

process analysis.
Simply enter the required information in sequence to easily create the analysis information.

▌ Extremely Simple Operation

Simply mount a sample in the spark stand, enter the sample number, and press the start button to display the analysis results on the screen in just over ten seconds. (The actual analysis time
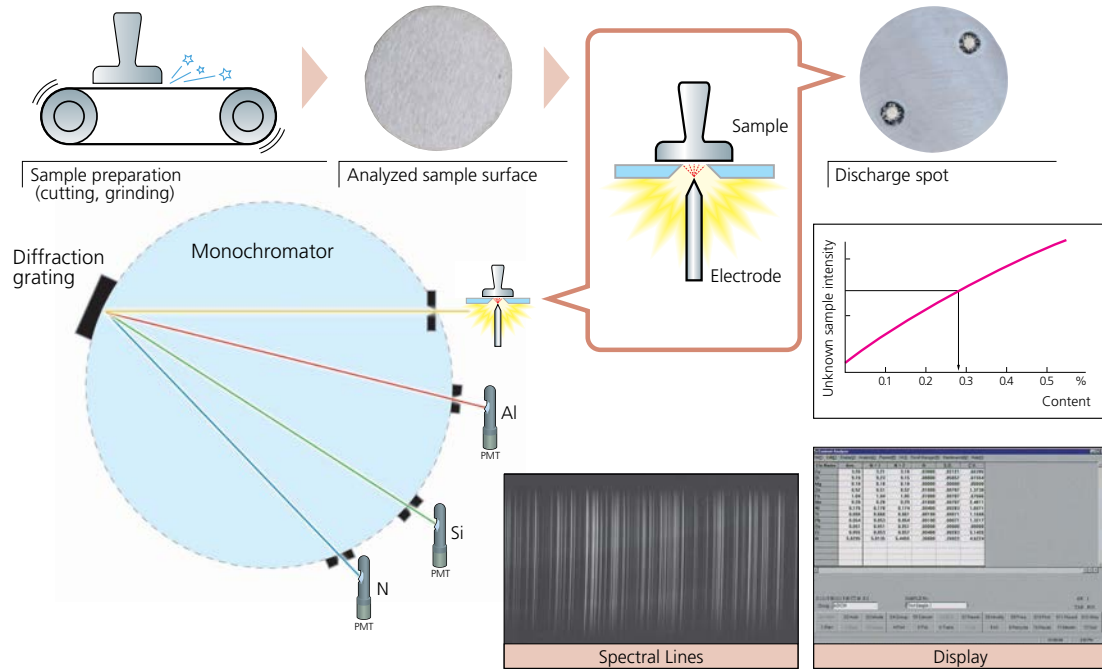
depends on the analysis conditions.)
The analysis data can be easily converted for flexible processing by commercial software.

Principle of Optical Emission Spectrometry

In optical emission spectrometry, electrical energy is imparted to a metal sample and the vaporized atoms are excited to obtain emission spectra unique to the elements. These emission spectra are separated by a monochromator and a detector (photomultiplier tube) detects the presence and intensity of each for quantification and qualification of the elements contained in the sample. This analy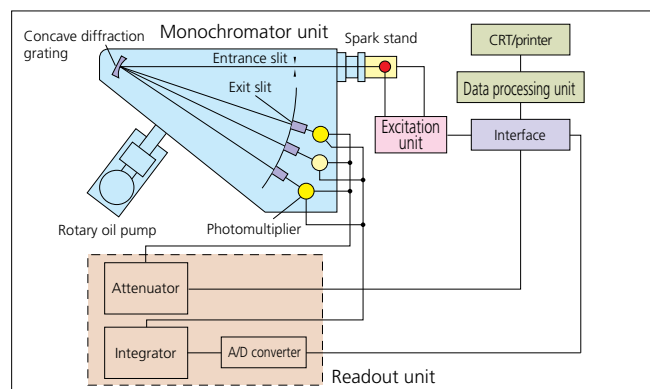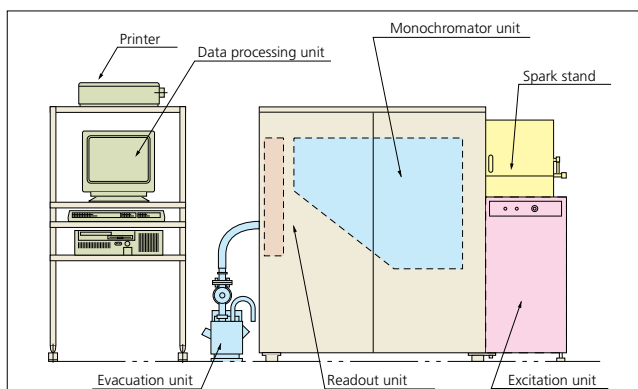sis method requires no complex pretreatment and obtains quantitative values for several tens of elements within one minute of starting analysis.

Shimadzu optical emission spectrometers use a unique process to obtain analysis results in just over ten seconds after starting analysis. Optical emission spectrometers using photoelectric photometry are prescribed in the Japan Industry Standards (JIS) and are adopted for a wide range of official analyses.

Sample preparation (cutting, grinding)

Analyzed sample surface

Sample

Electrode

Discharge spot

Diffraction grating

Monochromator

Al PMT

Si PMT

N PMT

Unknown sample intensity

0.1 0.2 0.3 0.4 0.5 %
Content

Spectral Lines

Display

Configuration

The PDA Series comprises the following parts:
- Excitation unit : The spark stand generates sparks between the sample and the counter electrode. Emission spectra of the elements in the sample are introduced into the monochromator unit.
- Monochromator unit : Splits the light into emission spectral lines. A sensor converts this light into electric currents.
- Readout unit : Measures the generated photocurrents.
- Data processing unit : Analyzes and processes the measured data.

Printer

Data processing unit

Monochromator unit

Spark stand

Evacuation unit

Readout unit

Excitation unit

Concave diffraction grating

Monochromator unit

Entrance slit

Exit slit

Spark stand

CRT/printer

Data processing unit

Excitation unit

Interface

Rotary oil pump

Photomultiplier

Attenuator

Integrator

A/D converter

Readout unit

Applications of Optical Emission Spectrometry

The Optical Emission Spectrometer covers a wide analysis range from trace levels to high concentrations of metals – including steel, aluminum, magnesium, copper, zinc, lead, tin, titanium, nickel, and cobalt – in ingots or alloy components.

It is used for process-control analysis and for raw materials delivery and product dispatch inspections in the metals refining and processing industries.

Ferrous Applications

Steel
- Quality control by rapid in-furnace analysis at each stage of manufacture
- Analysis for product standards evaluation
- Materials deliver inspections

Cast Iron
- Quality control by rapid in-furnace analysis at each stage of manufacture
- Analysis for product standards evaluation
- Materials deliver inspections

Non-ferrous Applications

Aluminum Ingot and Rolling Industries
- Quality control by rapid in-furnace analysis at each stage of manufacture
- Analysis for product standards evaluation
- Materials deliver inspections

Other Metals
- Quality control by rapid in-furnace analysis at each stage of manufacture
- Analysis for product standards evaluation
- Materials deliver inspections

Machinery, Automobile, and Ship-building Applications
- Analysis for product standards evaluation
- Materials deliver inspections

Options

Extensive options are available to handle a variety of analyses.

▌ Electrode-cleaning Unit (PDA-7000)

To enhance long-term stability, the optional electrode-cleaning unit keeps the counter electrode clean by brushing away adhering sample deposits. The attached sample retainer mechanism allows anyone to set samples under identical conditions.

sample retainer mechanism

Brush

Brush

Electrode
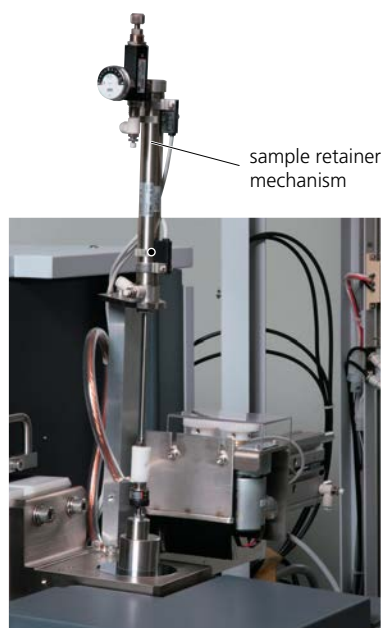
Sample cleaning unit

▌ Stand Water-cooling Kit (PDA-7000) (P/N: 211-74666-92)

Enhances the stability of the measured values by restricting the spark stand temperature rise due to electrical discharge during continuous analysis.
(Especially effective for accurate analysis of ultra low nitrogen.)

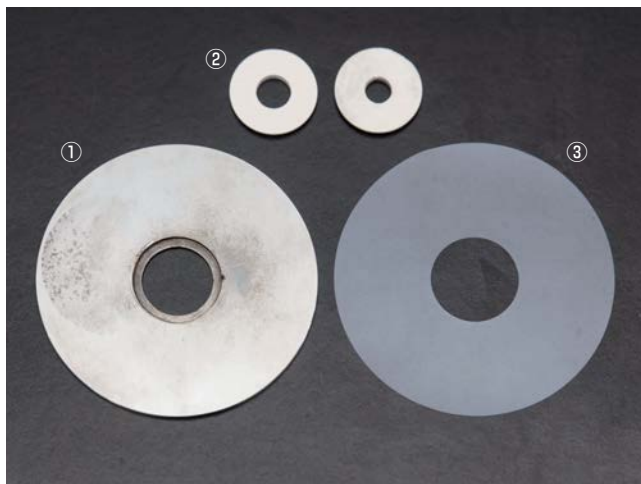

▌ Water cooling unit, CCA-1111 (P/N: 044-01809-05)

Power supply:Single-phase 100 V,50/60 Hz,8 A

Not required when tap water of certain spec is supplied.

▌Small-sample Analysis Kit (P/N: 211-74665-**)

Handles samples between 3 mm and 12 mm in diameter.

① Sample plate

② Insulation washer(Consumable part)
Hole size :2.3.4.5.6.7 and 8mm diameter
Selective according to the sample size.

③ Mylar(Consumable part)
Ensures insulation by putting it between sample
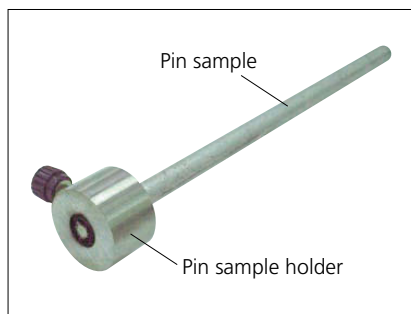and sample plate.

Parts

Pile up in order of ①, ② ③and.

Set on the spark stand

Effective for analysis of small samples.

▌Pin Sample Kit (P/N: 211-74594)

Handles wire and bolt samples
between 0.6 mm and 12 mm in diameter.

Pin sample

Pin sample holder

Options

▌ Factory Calibration [FC] (PDA-7000) (Note 1)

		Internal calibration curves	
Type	Steel : 10 types	FC Low-alloy steel	211-53955-01
		FC Austenitic stainless steels	211-53955-02
		FC Ferrite stainless steels	211-53955-03
		FC Low-alloy cast iron	211-53955-04
		FC Free-cutting steels	211-53955-05
		FC High-manganese steels	211-53955-06
		FC High-speed tool steels	211-53955-07
		FC High-alloy cast iron	211-53955-08
		FC Ni-resist cast iron	211-53955-09
		GC Steel	Note 2
Type	Aluminum alloy : 6 types	Low-alloy Al Al – Cu	
		Al – Si Al – Zn	
		Al – Si – Cu Al – Mg	
Type	Copper alloy : 8 types	FC Bronze	211-53956-01
		FC Gun Metal	211-53956-02
		FC Aluminum Bronze	211-53956-03
		FC Brass	211-53956-04
		FC Silicon Brass	211-53956-05
		FC Pure Copper	211-53956-06
		FC Nickel Silver	211-53956-07
		FC Capro Nickel	211-53956-08

Consult your Shimadzu representative about other metals.

▌ Factory Calibration [FC] (PDA-5500S) (Note 1)

		Internal calibration curves	
Type	Steel : 5 types	FC (Low Alloy)	211-79300-01
		FC (Stainless)	211-79300-02
		FC (Low Alloy Cast)	211-79300-03
		FC Mn (H) steel	211-79300-04
		FC Cr (H) cast	211-79300-05
Type	Aluminum : 5 types	FC AI-Si ADC1-4	211-79306-01
		FC AI-Mg ADC5-6	211-79306-02
		FC AI-Si Cu ADC8-12	211-79306-03
		FC AI-Zu-Mg	211-79306-04
		FC AI-Zn-Mg-Cu	211-79306-05

Note 1: Must be ordered with the instrument.

Note 2: The following two items are required for GC steel: 1. Global Calibration (GC), steel (P/N: 211-53953)

2. 31 for global standardization (P/N: 210-00004-31)

Standard Samples for Analysis

Contact your Shimadzu representative for information on the selection and preparation of standard samples for each analysis purpose. Also consult Shimadzu if chemical analysis is required.

Cast Aluminum Standard Samples

Cast aluminum standard samples for standardization (disk type), set of 5 (P/N 080-94801-21)
Standard accessory with PDA Series, Al base fixed channel.

Shapes of Cast Aluminum Standard Samples

Pechiney type

Disk type
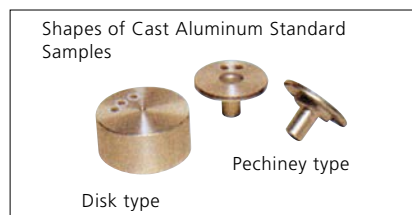
Cast Iron Standard Samples

These standard samples are created using Shimadzu's many years of research and experience. They are white pig iron samples of alloy cast iron and normal cast iron, offering highly reliable carbon analysis and an adequate concentration range of component elements for optical emission spectrometry.
• No. 23 Cast iron standard sample for standardization (mushroom type), 3 sets of 3 each (P/N 210-00004-23)
One set of 3 supplied as standard accessory with PDA Series, Fe base fixed channel.
• No. 21 Cast iron standard sample for calibration curves (mushroom type), set of 10 (P/N 210-00004-21)

Shapes of Cast Iron Standard Samples

Disk type   Mushroom type
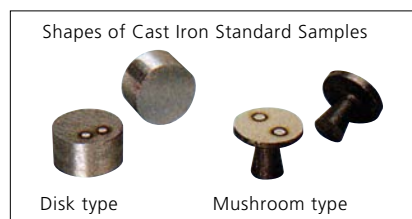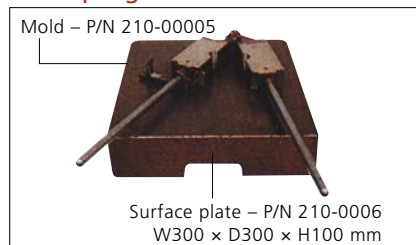
Low-alloy Steel Standard Samples

These standard samples contain many component elements in concentration ranges found in actual low-alloy steels. The concentrations are strictly controlled to ensure high reliability.
• No. 14 Low-alloy steel standard sample for standardization (disk type), set of 3 (P/N 239-00100-06)
Supplied as standard accessory with PDA Series, Fe base fixed channel.
• No. 5 Low-alloy steel standard sample for calibration curves (disk type), set of 10 (P/N 210-00004-05)

No. 5 Low-alloy Steel Standard Samples for Calibration Curves
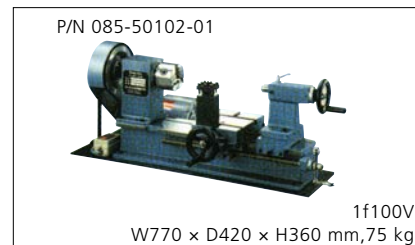
P/N 210-00004-05

No.14 Low-alloy Steel Standard Sample for Standardization

P/N 239-00100-06

Options for Sample Preparation

1. Sampling Mold and Surface Plate

Mold – P/N 210-00005

Surface plate – P/N 210-0006
W300 × D300 × H100 mm

2. FS-3NS Belt Sander

P/N 085-50206-01

3f200V 0.75kW
W420 × D680 × H830 mm,97 kg

3. L-1000 Bench Lathe

P/N 085-50102-01

1f100V
W770 × D420 × H360 mm,75 kg

Items 1) and 2) below must be ordered with the bench lathe.
1) O.D. holder   P/N 085-50102-12
(Tip holder)TCGCR/L1010F-08
2) Appropriate tip (non-ferrous)   P/N 085-50102-13
TCGT080202FR/L-U KW10
3) Bench lathe stand E-17   P/N 085-50102-11
Size: 1200(W) × 600(D) × 740(H) mm

Consumables

1. Tungsten electrode   P/N 211-74362-01
2. Brush   P/N 211-74965
3. Pump oil, 1 liter   P/N 017-30159-03

Tungsten electrode (6 mm dia.)

4. MT-11M Grinder
(for 6 mm dia. tungsten electrodes)

P/N 085-50802-01

1f100V 70W
W120 × D210 × H150 mm,3 kg
Grinding wheel P/N 085-50802-51

Major Specifications

Monochromator unit

Dispersion system	Paschen-Runge mounting for concave diffraction grating
Diffraction grating	Concave radius of curvature: 600 mm
	Number of grooves: 2400 grooves/mm
	121 to 481 nm and 589 nm
Wavelength range	Direct-linked rotary pump. Ultimate pressure: 2 Pa
Evacuation system Base	Fe or Al single base only (PDA-5500S)	Fe/Al/Cu/Zn/Pb/Sn/Mg/ Ni/Ti, etc. single or multi base (PDA-7000)

Factory calibration	Steel : 5 types available - FC (Low Alloy) - FC (Stainless) - FC (Low Alloy Cast) - FC Mn (H) steel - FC Cr (H) cast	Aluminum : 5 types available - FC Al-Si ADC 1-4 - FC Al-Mg ADC 5-6 - FC Al-Si Cu ADC 8-12 - FC Al-Zu-Mg - FC Al-Zn-Mg-Cu	Various types available (PDA-7000)

Excitation Unit

Discharge voltage	500 V or 300 V, selectable
Discharge frequency	One of three frequencies automatically set for the discharge conditions. 400 Hz max.
Voltage accuracy	Main voltage ± 1% However, input voltage coefficient of variation within ± 10%
Discharge conditions	6 types
Counter electrode cleaning	Automatic regeneration by reversing electrode polarity after each analysis
Spark stand	Stand for argon atmosphere

Readout unit

Number of light receptors (channels)	64 channels max. (PDA-7000) 24 channels max. (PDA-5500S)	
Method of measurement	Single-pulse integration method Time-resolution PDA photometry	
Gas channels	NOT applicable (PDA-5500S)	applicable (PDA-7000)

Data Processing Unit (Windows)

Windows Kit (P/N 211-72143-94)

Analysis processing	Content analysis, content 4x analysis, round analysis, grade evaluation PDA processing, internal standard method, co-existing element correction, master curve correction, re-standardization, calibration curve creation
Process control functions	Specification control, deviation control, X-R control, histograms
Host link	RS-232C, LAN(TCP/IP) (optional)
Report functions	Control charts, histograms, daily reports, batch transfers, file conversion
Maintenance Instrument management functions	Instrument check functions (vacuum, monochromator temperature) Lamp test function Counter electrode replacement, stand cleaning Management of inlet slit position according to number of discharges Management of pump oil replacement and igniter cleaning periods

Installation and Optional Accessories

Installed Environment
Area Approx. 3 × 2 m min.
Temperature Approx. 10°C to 28°C
Humidity 70% RH max.
Note Heat generation approx. 1100 kcal/hour
The instrument highly resistant to dust and other environmental factors. However, avoid installing the data processing unit in an environment subject to vibrations, dust, and strong electrical fields.

Power Supply
·200, 220, 230, or 240 V ± 10%, single-phase, 50/60 Hz, 4.0 kVA
·Ground: Individually grounded 30 W max. Provide near the rear of the instrument.

Gas
Argon gas : A central supply with switching between at least two cylinders is convenient.
Argon gas purity 99.999% min.
Dew point below –70°C.

Optional Accessories (Require separate installation locations and power supplies.)
 Sampling Mold and Surface Plate
·L-1000 Bench Lathe:100 V, 300 W, single-phase
·Belt Sander   :200 V, 750 W, three-phase
·Electrode grinder   :100 V, 70 W, single-phase
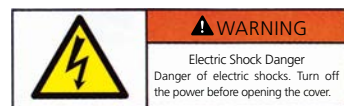·* See the Installation Guide for details.

External Dimensions and Weight

Plan View of Sample Installation   Units: mm
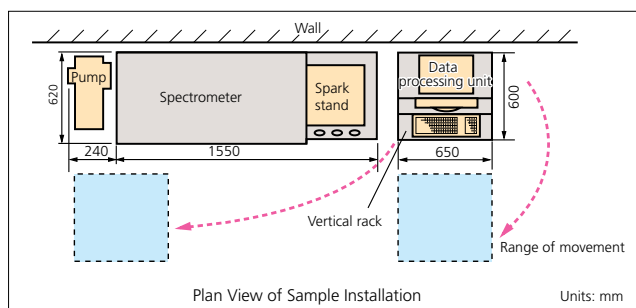
PDA instrument   1550 (W) × 620 (D) × 1330 (H) mm
Rotary oil pump   230 (W) × 475 (D) × 253 (H) mm
Data processing unit   650 (W) × 600 (D) × 1380 (H) mm
(When installed on PC rack.)
Weight (system)   Approx. 500 kg total

Note The instrument can be mounted against the wall to save space.
Maintenance can be conducted from the front.
The data processing unit can be moved near to the operated instrument.

Take due care of locations where this warning label is attached.

⚠ WARNING
Electric Shock Danger
Danger of electric shocks. Turn off the power before opening the cover.

Shimadzu Testing Machines

▍ Physical properties evaluation (Strength test / Fatigue and Endurance test)

High precision Universal tester
AG-Xplus Series

Designed for reliability and ease-of-use, these precision universal testers provide high control and measurement performance. For the three most important functions of a testing machine - setting, measurement, and inspection - enjoy the highest level of performance available. TRAPEZIUMX PC software uses the state-of-the-art . NET technology that is newly designed to ensure operation is easier than ever. Additionally, perform tests without a computer via a color TFT touch panel, use the USB memory function to directly set test parameters created previously on a PC, and then easily transfer result data to a USB device. Choose from several floor-type and tabletop models to fit your application needs.

AG-300kNXplus

Universal testing machines
UH-FX Series

Equipped as a standard with front-opening hydraulic grips, this series allows the performing of tensile testing with high efficiency. By adding options such as an automatic extensometer and data processing equipment, these models can be used as an automatic tensile testing system.

- Capacity : 200, 300, 500, 600, 1000, 2000, 3000 or 4000 kN (seven models)
- Test force control : Speed range : 0.2% to 500% full-scale/min
  Control range : 0.4% to 100% of full-scale force
- Test control functions : Single test control, Cycle test control (triangular wave, trapezoidal wave), Stress test control (metal tensile test control : compliant with ISO 6892-2009/JIS Z2241), Strain test control (metal tensile test control : compliant with ISO 6892-2009), Stroke speed 3-step switching control, Concrete test control (compression, bending, cleavage tests)

UH-FX 500kN

Micro Hardness Tester
HMV Series

The HMV-2 is an automatic test force switching feature that allows the touch panel to perform operations ranging from selecting the test force loading to the time duration of the test force. Models with an electric turret (HMV-2T) are capable of automatically switching from load application to surface viewing. Since it is directly linked with Windows, it allows the data to be exported to an Excel file.

- Test force Range : 98.07 mN to 19.61 N (HMV-2/2T)
- Min. Measurement Unit : 0.01 µm
- Type with Electric Revolver : (HMV-2T)

HMV-2

▶

SHIMADZU

Shimadzu Corporation

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