TCH600
Analytical Tips

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Analytical Tips for the LECO TCH600

Background

The TCH600 is a new development with revolutionary technology introduced by LECO Corporation in the year 2002. This is the first LECO analytical instrument, utilizing the inert gas fusion principle, designed to simultaneously determine O, N, and H in metals and other inorganic materials. The TCH600 utilizes a newly designed infrared (IR) cell to determine hydrogen (as H_2O). Historically, thermal conductivity (TC) cells have been used for accurate hydrogen determination in metals. A TC cell is a very sensitive and generally linear detection device, however it is a “universal” detector that cannot tell the difference between various gases unless they are separated by some means. Therefore other gases, such as carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen (N_2) must be either removed or separated from hydrogen (H_2) for proper measurement. In addition, a TC cell works in conjunction with an inert carrier gas and determines the analyte of interest by the thermal conductivity difference of the carrier gas and the analyte. Therefore, the carrier gas must have significant difference in thermal conductivity to allow adequate detection. Generally, argon (Ar) has been used as a carrier gas in an impulse electrode furnace system (RH1, RH404). The CO that is released during the fusion of a sample is converted to CO_2 by passing it over Schutze reagent (iodine pentoxide on silica gel). This conversion takes place at room temperature and does not effect either the H_2 or N_2 released from a sample. The CO_2 that is produced is removed with Lecosorb (sodium hydroxide on a clay base). The N_2 cannot be removed; therefore it is separated from the H_2 by passing the gas stream through a long column. The H_2 elutes from the column first and is passed through the measure side of the TC cell for measurement. The N_2 elutes from the column approximately 45 seconds after the hydrogen has been measured and is not measured. Since N_2 and Ar have similar thermal conductivity, low levels of nitrogen cannot be accurately determined using Ar as a carrier. Helium (He) is usually used as a carrier gas when nitrogen measurement is desired. However, since He and H_2 have similar thermal conductivity it is not practical to determine hydrogen using a He carrier gas. This is the reason that accurate simultaneous hydrogen and nitrogen determination using a TC cell is not feasible.

The TCH600 has changed all of this! LECO has developed new IR technology that can detect hydrogen, as water (H_2O), at low levels. IR cells are selective detectors that are designed to detect only the analyte of interest and function well in a variety of carrier gasses. This has led to a new instrument design using a He carrier gas, IR detectors for oxygen and hydrogen, and a TC cell for nitrogen determination. A true simultaneous O, N, and H determinator is now a reality.

Analytical Considerations

Traditional analytical applications using the inert gas fusion method have centered on simultaneous N and O, and H-only determination. There are differences in the analytical approach used and this is an area of concern. The carbon from the crucible readily reduces oxygen; nitrogen typically requires higher temperatures for adequate release, while hydrogen is generally released at lower temperatures. Tin flux, added directly to the crucible, is typically used for hydrogen determination. The main reason tin is used is to prevent crucible penetration by the sample. Crucible penetration can result in erratic oxygen and hydrogen results and may cause low nitrogen recovery. The prevailing theory is that trace amounts of moisture not removed during outgas cycle of the graphite crucible is responsible for the erratic oxygen and hydrogen results. This means that appropriate precautions must be used to identify and minimize crucible penetration. In addition, the purity of the graphite used in the manufacture of these crucibles is very important. LECO’s quality assurance procedures and ongoing research programs assure that LECO will provide the highest quality crucibles for the widest array of applications.

Reduction of furnace power is usually the first adjustment that is made when crucible penetration is evident. However, care must be taken to assure that adequate analyte recovery is maintained. In some cases the problem is related to furnace electrode alignment and/or condition. Double and even triple outgas of the crucible (operator selectable in method parameters) will generally improve instrument performance. The graphite crucible will be subjected to multiple heat/cool cycles during the outgas phase, lowering the trace crystalline water content of the crucible, subsequently reducing the potential for erratic crucible blank. Using the dual wall “heater” crucibles will tend to improve low level oxygen (and hydrogen) determination because the current passes through the outer crucible and the sample melts in the inner crucible. This design minimizes penetration of the outer crucible, thus reducing the potential for erratic blanks. The major drawback of this crucible is that it has a maximum temperature capability of ~2200°C, which is insufficient for complete nitrogen recovery in many alloys.

On the RH1 and RH404 Hydrogen Determinators, a 0.5 g tin pellet is added as a flux to the graphite crucible prior to the outgas cycle. The tin coats the inside of the crucible eliminating crucible penetration. This enhances hydrogen recovery and minimizes any additional contribution from the crucible. Unfortunately, this procedure reduces nitrogen recovery and produces a significant amount of tin dust. Oxygen recovery and precision is typically improved with the use of tin flux.

With the advent of the new TCH600, the goal is to find procedures that will permit simultaneous O, N, and H determination. We have been able to obtain suitable simultaneous O, N, and H results on the TCH600 when analyzing steel samples using the 776-247 Crucible. The key is customizing the furnace and analysis parameters to assure adequate recovery without crucible penetration/ breakdown. Crucible penetration/breakdown will typically happen on a TC-436 or TC600 at the end of the analysis cycle, and may not cause any “noticeable” analytical problems because the oxygen peak comes over within 35 seconds and oxygen integration is over by then. However, on the TCH600, the hydrogen peak may take up to 70 seconds to complete its cycle. When the crucible starts to break down near the end of this time, a second hydrogen peak may be noticed. The integration time may continue for a long time (keeping the furnace on), depending on the comparator setting, causing an artificially high hydrogen result. This is due to the crucible releasing additional hydrogen (and oxygen). If the oxygen minimum time were extended to match that of the hydrogen, a coincidental second oxygen peak would be noted as well.

The importance of carrier gas purity is also an issue that can not be overlooked. The incoming gas purifier, consisting of heated copper metal, is of key importance. The Supelco finish scrubber is another key component for improved performance. Removal of trace amounts of oxygen and moisture from the He carrier gas will ensure proper performance. Therefore, fresh reagents in these scrubbers are a pre-requisite for proper instrument performance. The particle filter (Balston) located above the filter disc assembly should be replaced with the 4-inch bubble tube filled with Anhydrone. This will trap any moisture released during the crucible outgas cycle, preventing possible baseline problems with the H_2O IR cell. Another important item is the copper oxide catalyst. Copper oxide wire (502-190) must be used instead of rare earth copper oxide (501-170) on the TCH600. The rare earth copper oxide has a clay support system that will act as a column and retard the hydrogen peak. The TCH600 has a newly designed electrode cooling system. This system has both an internal radiator and a new liquid-to-liquid heat exchanger that can be connected to a tap water source and drain. We recommend that the external cooling system be connected for enhanced analytical performance and stability.

Analytical Procedures/Steel Samples

The following shows a good starting point for analyzing steel samples on the TCH600.

Crucible	776-247
Sample Weight	1 gram (nominal)

Analysis Parameters

Outgas Cycles	3
Analysis Delay	20 seconds
Analysis Delay Comparator	1.000
Analysis Type	Auto Analysis

Element Parameters	*Oxygen*	*Nitrogen*	*Hydrogen*
Minimum Analysis Time	40 seconds	60 seconds	60 seconds
Significant Digits	5	5	6
Conversion Factor	1.00000	1.00000	1.00000
Integration Delay	10 seconds	20 seconds	15 seconds
Comparator Level	1.00000	1.00000	5.00000

Furnace Parameters

Furnace Control mode	Power
Purge Time	15 seconds
Outgas Time	10 seconds
Outgas Cool Time	—
Outgas Low Power	5800 watts
Outgas High Power	5800 watts
Outgas Ramp Rate	—
Analyze Low Power	4800 watts
Analyze High Power	4800 watts
Analyze Ramp Rate	—
Sample Prep Time	—
Sample Prep Power	—
Temperature Sustain	None

Using these parameters should produce good O, N, and H results in a steel sample. As mentioned earlier, if crucible penetration/breakdown is excessive, the furnace power will have to be reduced. If, on the other hand, nitrogen recovery is low (usually evidenced by peak trailing) the furnace power may have to be increased. Currently, there are few steel standards with O, N, and H values assigned; however, there are some O and N calibration samples that have repeatable hydrogen values. LECO is currently producing O, N, and H calibration standards. Due to the mobile nature of hydrogen in plain carbon and low alloy steels, it is difficult to obtain steel with a suitable amount of hydrogen content. Austenitic stainless steel will retain hydrogen for extended periods of time, which makes it a candidate for use as a hydrogen standard. LECO's hydrogen steel standards are stainless steel. Hydrogen content in steel is typically less than 5 ppm, which contrasts with the wide range of oxygen and nitrogen contents found in the wide variety of steel products. Likewise, obtaining material in a form that can be made into a suitable standard with suitable homogeneity of the elements of interest will be a challenge.

Sampling and Sample Preparation/Steel Samples

Sampling and sample preparation is of some concern because traditional methods used to obtain samples for oxygen and nitrogen are different than those used for hydrogen, especially when sampling from molten metal. ASTM E1806 and ISO 14284 are sampling and sample preparation documents that are an excellent source of information. The main difference in steel sampling procedures for oxygen/nitrogen and hydrogen is due to the mobility of hydrogen. Special precautions must be used when sampling for hydrogen. From molten metal a sample must be quickly quenched in water and stored in a refrigerant—such as liquefied nitrogen, or a mixture of acetone and solid carbon dioxide—in order to reduce losses of hydrogen from diffusion. Losses of oxygen and nitrogen from diffusion are not a problem. The sample that is taken for hydrogen and chilled in a refrigerant can also be used for oxygen and nitrogen determination. However, the sample that is generally taken for nitrogen and/or oxygen is not suitable for hydrogen determination due to hydrogen loss (diffusion). In any event, the surface of the sample must be prepared by filing or light grinding, using care not to overheat the sample. The sample is washed in a suitable solvent such as acetone and dried with warm air. The prepared sample should be analyzed immediately after preparation.

Typical Results

The results represented below were obtained on a LECO TCH600 with auto-cleaner and batch loader installed. The samples are LECO steel pins analyzed in 776-247 Crucibles. The 501-529 Sample is a stainless steel, non-plated 1 g pin, with an assigned hydrogen value of 5.0 ±0.3 ppm (oxygen and nitrogen not determined). The 502-257 Sample is a stainless steel nickel-plated 1 g pin, with an oxygen value of 27 ±3 ppm and a nitrogen value of 450 ±12 ppm (hydrogen not determined). The 1018 steel pellet sample is a nickel-plated 1 g pellet that is in the preliminary stages of development for possible use as a calibration sample. Note the excellent precision obtained on these steel samples for all three elements determined simultaneously.

LECO 501-529 Stainless Steel Pin

Name	Mass	Oxygen ppm	Nitrogen ppm	Hydrogen ppm	Analysis Date	Method
501-529 (J0287-1)	1.0011	56.7	148	5.09	5/8/2002 9:10:27 AM	Standard-ONH
501-529 (J0287-1)	1.0017	59.2	150	5.01	5/8/2002 9:14:20 AM	Standard-ONH
501-529 (J0287-1)	1.0006	56.4	143	5.02	5/8/2002 9:18:13 AM	Standard-ONH
501-529 (J0287-1)	1.0020	56.4	148	5.00	5/8/2002 9:22:07 AM	Standard-ONH
501-529 (J0287-1)	1.0032	57.8	154	5.18	5/8/2002 9:25:59 AM	Standard-ONH
501-529 (J0287-1)	1.0027	56.2	146	4.98	5/8/2002 9:29:52 AM	Standard-ONH
501-529 (J0287-1)	1.0022	56.3	144	5.01	5/8/2002 9:33:44 AM	Standard-ONH
501-529 (J0287-1)	1.0010	57.4	145	4.87	5/8/2002 9:37:36 AM	Standard-ONH
501-529 (J0287-1)	1.0014	56.9	148	4.96	5/8/2002 9:41:29 AM	Standard-ONH
501-529 (J0287-1)	1.0031	57.2	143	5.01	5/8/2002 9:45:22 AM	Standard-ONH

Element	Average	Std. Deviation	RSD
Oxygen	57.050	0.91924	1.6113
Nitrogen	146.90	3.4464	2.3461
Hydrogen	5.0130	0.080561	1.6070

LECO 502-257 Plated Stainless Steel Pin

Name	Mass	Oxygen ppm	Nitrogen ppm	Hydrogen ppm	Analysis Date	Method
502-257 (J0385-3)	1.0017	27.1	449	3.12	5/8/2002 9:49:15 AM	Standard-ONH
502-257 (J0385-3)	0.9997	26.7	443	2.82	5/8/2002 9:53:08 AM	Standard-ONH
502-257 (J0385-3)	1.0006	27.1	451	3.09	5/8/2002 9:57:00 AM	Standard-ONH
502-257 (J0385-3)	1.0016	27.5	449	3.25	5/8/2002 10:00:52 AM	Standard-ONH
502-257 (J0385-3)	1.0002	26.7	451	3.07	5/8/2002 10:04:44 AM	Standard-ONH
502-257 (J0385-3)	1.0023	26.8	455	2.99	5/8/2002 10:08:36 AM	Standard-ONH
502-257 (J0385-3)	1.0027	26.7	453	3.08	5/8/2002 10:12:29 AM	Standard-ONH
502-257 (J0385-3)	1.0028	26.8	451	3.24	5/8/2002 10:16:21 AM	Standard-ONH
502-257 (J0385-3)	1.0039	27.4	448	2.99	5/8/2002 10:20:13 AM	Standard-ONH
502-257 (J0385-3)	1.0029	26.9	448	3.00	5/8/2002 10:24:04 AM	Standard-ONH

Element	Average	Std. Deviation	RSD
Oxygen	26.970	0.29458	1.0923
Nitrogen	449.80	3.2592	0.72458
Hydrogen	3.0650	0.12660	4.1305

LECO Preliminary Plated 1018 Steel Pellet

Name	Mass	Oxygen ppm	Nitrogen ppm	Hydrogen ppm	Analysis Date	Method
A082346	1.0036	23.1	35.5	1.89	5/8/2002 10:27:58 AM	Standard-ONH
A082346	1.0028	22.5	35.2	1.58	5/8/2002 10:31:52 AM	Standard-ONH
A082346	1.0027	21.9	33.2	1.78	5/8/2002 10:35:45 AM	Standard-ONH
A082346	1.0037	22.2	34.5	1.73	5/8/2002 10:39:38 AM	Standard-ONH
A082346	0.9993	21.4	35.9	1.37	5/8/2002 10:43:30 AM	Standard-ONH
A082346	1.0005	22.3	32.2	1.54	5/8/2002 10:47:21 AM	Standard-ONH
A082346	1.0049	24.3	35.6	1.99	5/8/2002 10:51:14 AM	Standard-ONH
A082346	1.0023	22.1	35.4	2.08	5/8/2002 10:55:10 AM	Standard-ONH
A082346	1.0002	22.8	35.4	2.01	5/8/2002 10:59:02 AM	Standard-ONH
A082346	1.0049	23.8	33.7	1.77	5/8/2002 11:02:55 AM	Standard-ONH

Element	Average	Std. Deviation	RSD
Oxygen	22.640	0.88468	3.9076
Nitrogen	34.660	1.2313	3.5524
Hydrogen	1.7740	0.22780	12.841

Analytical Procedures/Titanium and Zirconium

The following shows a good starting point for analyzing reactive/refractory metal samples such as titanium and zirconium on the TCH600.

Crucible	776-247, with ~75 to 150 mg of 501-073 Graphite Powder
Sample Weight	0.10 to 0.15 gram, placed into 502-344 Nickel Basket

Analysis Parameters

Outgas Cycles	3
Analysis Delay	20 seconds
Analysis Delay Comparator	1.000
Analysis Type	Auto Analysis

Element Parameters	*Oxygen*	*Nitrogen*	*Hydrogen*
Minimum Analysis Time	40 seconds	60 seconds	60 seconds
Significant Digits	5	5	6
Conversion Factor	1.0000	1.0000	1.0000
Integration Delay	10 seconds	20 seconds	15 seconds
Comparator Level	1.00000	1.00000	5.00000

Furnace Parameters

Furnace Control Mode	Power
Purge Time	15 seconds
Outgas Time	10 seconds
Outgas Cool Time	—
Outgas Low Power	6000 watts
Outgas High Power	6000 watts
Outgas Ramp Rate	—
Analyze Low Power	5200 watts
Analyze High Power	5200 watts
Analyze Ramp Rate	—
Sample Prep Time	—
Sample Prep Power	—
Temperature Sustain	None

Using these parameters should produce good O, N, and H results in reactive/refractory metals such as titanium and zirconium. As mentioned earlier, if crucible penetration/breakdown is excessive, the furnace power must be reduced. If nitrogen recovery is low, usually evidenced by peak trailing, the furnace power will have to be increased. This is a slight departure from the method that has been recommended for over 10 years when determining O and N in reactive/refractory metals on the TC-436 and TC600-Series. Typically we have recommended that the 782-720 High-Temperature Crucible be used for these material types, due to the increased temperature capability of this crucible. However, recent experiments have shown that the 776-247 Crucible will produce excellent O, N, and H results on titanium and zirconium material. The main advantage of the 776-247 Crucible is that it produces much less carbon dust (soot) in and around the electrode area compared to the 782-720 Crucible. This is an advantage when the auto-cleaner option is installed on the TCH600.

Sampling and Sample Preparation/Titanium and Zirconium Samples

Sampling and sample preparation of titanium and zirconium is somewhat different from that of steel. Unlike steel samples, hydrogen is not as mobile in titanium and zirconium; therefore storage in liquid nitrogen or dry ice is not required. However, it is important to keep the sample cool when cutting or sectioning. Sample preparation for oxygen and nitrogen determination has been different from that for hydrogen determination. Typically, titanium and zirconium samples are chemically etched to remove surface oxides when oxygen and nitrogen are determined. However, etching can introduce hydrogen into a sample. ASTM Method E1409 "Determination of Oxygen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique", as updated in 1996, permits either etching or abrading (filing) of the test specimen. ASTM E1937 "Determination of Nitrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique", indicates that the test specimen be etched. ASTM E1447 "Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity Method", permits surface preparation by abrading (if necessary to remove contamination). Please refer to the appropriate ASTM method(s) for details. The difference in sample preparation does present somewhat of a dilemma regarding simultaneous determination of O, N, and H in titanium. However, abrading samples with a file to remove surface contamination should yield accurate O, N, and H results.

Typical Results

The results given below were obtained on a LECO TCH600 with (optional) auto-cleaner, using the parameters listed above. The 502-201 Titanium 0.1 gram pin is an O and N calibration sample with assigned values of 0.267% O (2670 ppm), and 0.017% N (170 ppm). hydrogen content was not established on this sample. The 502-047 Zirconium 0.1 gram pin is a 0.13% O-only calibration sample. The 762-741 Titanium 0.24 gram pin is an H-only calibration sample. This pin was cut in half to obtain a nominal sample weight of 0.12 gram. The precision obtained on all of these samples is very good, and comparable to results obtained on the TC600 (O and N only) and the RH-404 (H only) instruments. The data illustrates the simultaneous O, N, and H capability of the TCH600 for refractory/reactive metals.

LECO 502-201 Titanium Pin

Name	Mass	Oxygen ppm	Nitrogen ppm	Hydrogen ppm	Analysis Date	Method
502-201	0.1143	2685	174	11.15	6/4/2002 3:49:24 PM	Refractory-ONH
502-201	0.1138	2672	161	11.39	6/4/2002 3:52:53 PM	Refractory-ONH
502-201	0.1139	2663	174	11.32	6/4/2002 3:56:20 PM	Refractory-ONH
502-201	0.1142	2663	172	12.49	6/4/2002 3:59:53 PM	Refractory-ONH
502-201	0.1146	2689	167	11.84	6/4/2002 4:03:27 PM	Refractory-ONH
502-201	0.1126	2694	173	12.42	6/4/2002 4:06:56 PM	Refractory-ONH
502-201	0.1149	2645	170	11.90	6/4/2002 4:10:24 PM	Refractory-ONH
502-201	0.1145	2657	172	11.45	6/4/2002 4:13:56 PM	Refractory-ONH
502-201	0.1140	2673	164	11.67	6/4/2002 4:17:30 PM	Refractory-ONH
502-201	0.1144	2658	171	11.63	6/4/2002 4:21:01 PM	Refractory-ONH

Element	Average	Std. Deviation	RSD
Oxygen	2669.9	15.673	0.58704
Nitrogen	169.80	4.4171	2.6014
Hydrogen	11.726	0.44804	3.8209

LECO 502-047 Zirconium Pin

Name	Mass	Oxygen ppm	Nitrogen ppm	Hydrogen ppm	Analysis Date	Method
502-047	0.1086	1312	28.1	19.13	6/4/2002 1:57:27 PM	Refractory-ONH
502-047	0.1111	1308	28.3	19.77	6/4/2002 2:01:27 PM	Refractory-ONH
502-047	0.1103	1305	28.7	19.63	6/4/2002 2:05:01 PM	Refractory-ONH
502-047	0.1141	1313	27.6	19.97	6/4/2002 2:08:39 PM	Refractory-ONH
502-047	0.1110	1301	24.9	18.64	6/4/2002 2:12:12 PM	Refractory-ONH
502-047	0.1096	1313	28.9	19.97	6/4/2002 2:15:42 PM	Refractory-ONH
502-047	0.1125	1309	28.5	19.73	6/4/2002 2:19:14 PM	Refractory-ONH
502-047	0.1052	1310	27.2	19.30	6/4/2002 2:22:47 PM	Refractory-ONH
502-047	0.1003	1308	27.1	19.58	6/4/2002 2:26:26 PM	Refractory-ONH
502-047	0.1132	1316	28.8	20.40	6/4/2002 2:30:02 PM	Refractory-ONH

Element	Average	Std. Deviation	RSD
Oxygen	1309.5	4.3525	0.33238
Nitrogen	27.810	1.2087	4.3463
Hydrogen	19.612	0.49351	2.5164

LECO 762-741 Titanium Pin

Name	Mass	Oxygen ppm	Nitrogen ppm	Hydrogen ppm	Analysis Date	Method
762-741	0.1369	462	108	20.88	6/4/2002 11:12:04 AM	Refractory-ONH
762-741	0.1419	468	109	20.41	6/4/2002 11:16:00 AM	Refractory-ONH
762-741	0.1244	476	115	21.80	6/4/2002 11:20:16 AM	Refractory-ONH
762-741	0.1122	480	120	20.87	6/4/2002 11:23:49 AM	Refractory-ONH
762-741	0.1310	469	121	20.31	6/4/2002 11:27:45 AM	Refractory-ONH
762-741	0.1154	468	116	21.43	6/4/2002 11:31:16 AM	Refractory-ONH
762-741	0.1253	475	119	20.69	6/4/2002 11:35:15 AM	Refractory-ONH
762-741	0.1206	470	124	21.70	6/4/2002 11:43:09 AM	Refractory-ONH
762-741	0.1159	473	115	20.42	6/4/2002 11:47:16 AM	Refractory-ONH
762-741	0.1037	485	131	21.78	6/4/2002 11:50:52 AM	Refractory-ONH

Element	Average	Std. Deviation	RSD
Oxygen	472.60	6.6700	1.4113
Nitrogen	117.80	6.8443	5.8101
Hydrogen	21.029	0.59655	2.8368

Specifications

Instrument Range at 1g*	
Oxygen:	0.05 ppm to 5.0%
Nitrogen:	0.05 ppm to 3.0%
Hydrogen:	0.1 ppm to 0.250%
Precision**	
Oxygen:	0.025 ppm or 0.5% RSD; whichever is greater
Nitrogen:	0.025 ppm or 0.5% RSD; whichever is greater
Hydrogen:	0.05 ppm or 2.0% RSD; whichever is greater
Readability	
Oxygen:	0.001 ppm
Nitrogen:	0.001 ppm
Hydrogen:	0.001 ppm
Calibration	standards, single or multi-point; manual; gas dose
Cycle Time	
Oxygen:	85 seconds nominal
Nitrogen:	100 seconds nominal
Hydrogen:	90 seconds nominal (includes purge/outgas/analysis)
Sample Size	1 g nominal
Detection Method	
Oxygen:	Non-dispersive infrared absorption
Nitrogen:	Thermal conductivity
Hydrogen:	Non-dispersive infrared absorption
Chemical Reagents	• Anhydrous Magnesium Perchlorate ($MgClO_4$) • Sodium Hydroxide on an inert base • Copper Oxide • Copper turnings • Supelco™ OMI Filter
Gases Required	
Carrier:	Helium, 99.99% pure, 20 psi ±10%
Pneumatic:	Compressed Air, 40 psi ±10%, source must be oil and water free
Dosing (optional):	Carbon Dioxide, 99.99% pure, 20 psi ±10% Nitrogen, 99.99% pure, 20 psi ±10%
Gas Flow Rates	
Carrier:	485 cc/minute
Pneumatic:	280 cc/analysis
Furnace	
Type:	Electrode furnace; current, power, and temperature control
Power:	7500 Watts, maximum

External PC (Min. Requirements)	
CPU:	Pentium® II
RAM:	64 MB
Speed:	200 MHz
Operating Sys:	Windows® 2000
Hardware:	USB support and 2 serial ports
Hard Drive:	2 GB
Display (external)‡	Flat panel (15-inch), 800 x 600 pixels
Data Storage	
Weight List:	No practical limit
Result List:	No practical limit
Printer (external)	Color Deskjet Printer (optional) Dot Matrix Printer (optional)

Single Furnace/Determinator Dimensions

31 in. H x 26 in. W x 30 in. D (79 x 66 x 76 cm)

Electrical Power Requirements	
Determinator:	230 V~ (±10%) @ 40A
Computer:	115/230 V~ (±10%), 50/60 Hz, 5/3 A
Monitor:	90 to 264 V~, 50/60 Hz, 1.6 A
Weight (approximate)	
TCH600	410 lb. (180 kg)
Total Shipping	460 lb. (250 kg)

Part Numbers

TCH600C	Oxygen/Nitrogen/Hydrogen Determinator with Windows®-based software, free-standing PC, and flat panel display

Options

617-970	Autocleaner Kit
621-527	Cassette Autoloader/Autocleaner Kit
619-901	Batch Autoloader Kit
619-902	Batch Autoloader/Autocleaner Kit
751-300-160	L-250 Balance and Interface Kit (0.1 mg)
750-000-160	L-050 Balance and Interface Kit (1.0 mg)
764-216	Helium Regulator
768-593	CO_2 Regulator
766-036	Air Regulator
615-763	SmartLine® Modem-Based Remote Diagnostics
710-198-B/O	SmartLine Internet-Based Remote Diagnostics
621-434-110	Deskjet Printer Kit (110 V)
612-917	Dot Matrix Printer Kit (110 V); Serial

**The range may be extended beyond listed values.*

***One sigma, conformance tested by gas dose analysis.*

Display capability.

Allow a 6 in. (15 cm) minimum access area around all units.

‡Requires flat panel display.

V~ denotes VAC.

Theory of Operation

The TCH600 measures nitrogen, oxygen, and hydrogen in a wide variety of metals, refractories, and other inorganic materials, employing the inert gas fusion principle. The instrument features a Windows®-based operating system. A weighed sample, placed in a high-purity graphite crucible, is fused under a flowing helium gas stream at temperatures sufficient to release oxygen, nitrogen, and hydrogen. The oxygen in the sample, in whatever form present, combines with the carbon from the crucible to form carbon monoxide. The nitrogen present in the sample releases as molecular nitrogen, and any hydrogen present is released as hydrogen gas.

Oxygen Measurement

Oxygen is measured by infrared (IR) absorption. Sample gases first enter the IR module and pass through CO and CO_2 detectors. Oxygen present as either CO or CO_2 is detected. Following this, sample gas is passed through heated copper oxide to convert CO to CO_2 and any hydrogen to water. Gases then re-enter the IR module and pass through a separate CO_2 detector for total oxygen measurement. This configuration maximizes performance and accuracy for both low and high range. The instrument automatically chooses the optimum detection range.

Nitrogen Measurement

Nitrogen is measured by thermal conductivity (TC). Sample gases pass through heated copper oxide which converts CO to CO_2 and hydrogen to water. CO_2 and water are then removed with a Lecosorb/Anhydrone trap to prevent detection by the TC cell. Gas flow then passes through the TC cell for nitrogen detection.

Hydrogen Measurement

Hydrogen is measured by infrared absorption. Sample gases pass through heated copper oxide which converts CO to CO_2 and hydrogen to H_2O. Gases enter the IR module and pass through an H_2O detector for total hydrogen measurement.

Flow Diagram