AEROSPACE MATERIAL SPECIFICATION	AMS2769™	REV. D
	Issued 1996-02 Reaffirmed 2014-04 Revised 2020-09 Superseding AMS2769C	

Heat Treatment of Parts in a Vacuum

RATIONALE

AMS2769D results from making changes to frequency (3.2.3.2), load sensors (3.5.3.2), load sensors (3.5.3.3.2), load sensors (3.5.3.4), and vacuum atmosphere system purging (A.3.1). These changes were made to clarify the intent of the requirements.

1. SCOPE

1.1 Purpose

This specification establishes the requirements and procedures for heat treating parts in vacuum/partial pressure and shall be used as a supplementary document to primary heat treating specifications as applicable.

1.2 Application

This process has been used typically for the heat treatment of carbon and alloy steels, tool steels, corrosion-resistant steels, precipitation-hardening steels, super alloys, titanium, and other nonferrous alloys, but usage is not limited to such applications.

1.2.1 Heat treatment as used in this specification includes solution treatment, homogenizing, austenitizing, annealing, normalizing, hardening, tempering, aging, and stress relieving. This specification does not cover processes such as melting, brazing, diffusion bonding, coating, carburizing, or nitriding.

1.2.2 The objective of this process is to produce heat treated parts that have minimal surface contamination and alloy depletion.

1.3 Safety - Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

1.4 The provisions of this specification revision shall become effective 90 days after publication.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

For more information on this standard, visit
https://www.sae.org/standards/content/AMS2769D/

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2750 Pyrometry

AMS2759 Heat Treatment of Steel Parts, General Requirements

AMS2759/1 Heat Treatment of Carbon and Low-Alloy Steel Parts Minimum Tensile Strength Below 220 ksi (1517 MPa)

AMS2759/2 Heat Treatment of Low-Alloy Steel Parts Minimum Tensile Strength 220 ksi (1517 MPa) and Higher

AMS2759/3 Heat Treatment, Precipitation-Hardening Corrosion-Resistant, Maraging, and Secondary Hardening Steel Parts

AMS2759/4 Heat Treatment, Austenitic Corrosion-Resistant Steel Parts

AMS2759/5 Heat Treatment, Martensitic Corrosion-Resistant Steel Parts

AMS2773 Heat Treatment, Cast Nickel Alloy and Cobalt Alloy Parts

AMS2774 Heat Treatment, Wrought Nickel Alloy and Cobalt Alloy Parts

AMS2801 Heat Treatment of Titanium Alloy Parts

ARP1917 Clarification of Terms Used in Aerospace Metals Specifications

2.2 CGA Publications

Available from Compressed Gas Association, Inc., 4221 Walney Road, 5th Floor, Chantilly, VA 20151-2923, Tel: 703-788-2700, www.cganet.com.

CGA G-5.3 Commodity Specification for Hydrogen

CGA G-9.1 Commodity Specification for Helium

CGA G-10.1 Commodity Specification for Nitrogen

CGA G-11.1 Commodity Specification for Argon

3. TECHNICAL REQUIREMENTS

3.1 Pyrometry

Shall be in accordance with AMS2750.

3.1.1 Control Sensors

Furnace control sensors shall be suitably protected and be of a type compatible with the range of temperatures and vacuum conditions used.

3.1.1.1 The types shown in Table 1 shall not be used unprotected (bare wire, i.e., other than protective sheathed) above the temperatures shown in Table 1.

3.1.1.2 Use of other sensor types shall be approved by the cognizant engineering organization.

3.1.1.3 When used in metal or other sheaths, care shall be taken to ensure that chemical reaction will not occur between the sheath and the sensor wire.

Table 1 - Bare control sensor types versus maximum operating temperature

Type	Maximum Temperature °F	Maximum Temperature °C
K (Chromel-Alumel)[(1)]	2200	1204
N (Nicrosil-Nisil)[(1)]	2200	1204
Nickel-Nickel/Molybdenum	2300	1260
S,R (Platinum-Platinum/Rhodium)	2600	1427
B (Platinum/Rhodium-Platinum/Rhodium)	3100	1704
Tungsten-Tungsten/Rhenium	4000	2204

NOTES:
[(1)] Re-use of thermocouples shall comply with the current revision of AMS2750.

3.2 Furnace Equipment

The equipment shall conform to the requirements of the applicable heat treat specifications. The furnace components shall result in no detrimental metallurgical effects on the material processed during a normal production run as a result of vaporization or chemical reaction between the furnace components and the gases used to maintain partial pressure in the furnace.

3.2.1 Types of Vacuum Furnaces

Appendix A specifies exemptions and additions to this specification for the use of multi-cell vacuum furnaces as described below.

3.2.1.1 Single Chamber Furnace

A single chamber furnace is a furnace that has only one vacuum chamber and that only performs a single heat treatment process at a time. Appendix A shall not apply.

3.2.1.2 Multi-Chamber Furnace

A multi-chamber furnace is a furnace that has multiple chambers that may or may not be separated by vacuum sealed doors and that only performs a single heat treatment process at a time. Appendix A shall not apply.

3.2.1.3 Multi-Cell Furnace

A multi-cell furnace has one or more vacuum systems with multiple cells that can perform multiple heat treatment processes simultaneously. Appendix A shall apply.

3.2.2 Vacuum System

The vacuum pumping system shall have sufficient pumping capacity to evacuate the furnace to a pressure indicated in Table 2 for the materials being processed. It shall also maintain the desired level of vacuum during the soak time, and the entire heat treating process except for instances of outgassing that may occur during the heat up cycle, as referenced in 3.5.2.1. When processing using partial pressure, the furnace shall first be pumped down to a pressure of 100 microns or lower prior to heating.

3.2.2.1 Diffusion pumps shall be isolated from the main vacuum chamber to prevent back-streaming at chamber pressures above those recommended by the manufacturer of the furnace, pump, and/or pump oil which are typically below 100 microns.

3.2.2.2 Parts made of carbon and alloy steel, corrosion resistant steel, or tool steel may be processed in a furnace not operating within Table 2 vacuum operating ranges, provided the parts meet the surface contamination requirements in the applicable heat treatment specification. All other requirements of this specification shall be met.

Table 2 - Vacuum range as a function of processing temperature range for various alloys

Material	Processing Range °F	Processing Range °C	Operating Range Microns(6)(7)(8)
Carbon and Alloy Steels(9)	1000 to 1800	538 to 982	1 to 500(1)
Corrosion-Resistant Steels(9)			
Ferritic (12 to 17% Cr)	1200 to 1650	649 to 899	1 to 500(1)
Martensitic	1200 to 2050	649 to 1121	1 to 500(1)
Austenitic	1750 to 2050	954 to 1121	1 to 500(1)
Precipitation Hardening Steels(9)	850 to 2150	454 to 1177	1 to 500(1)(3)
Superalloys			
Nickel Alloys	1150 to 2275	621 to 1246	<10
Cobalt Alloys	1350 to 2250	732 to 1232	<10
Iron Alloys	1600 to 2150	871 to 1177	<500(2)(3)
Tool Steels(9)			
Air Hardening	1470 to 1850	799 to 1010	0.1 to 500(1)
Cold Work	1470 to 1950	799 to 1066	0.1 to 500(1)
Hot Work	1470 to 1900	799 to 1038	0.1 to 500(1)
High Speed (M Series)	1470 to 2250	799 to 1232	0.1 to 500(1)
High Speed (T Series)	1550 to 2375	843 to 1302	0.1 to 500(1)
Titanium and Titanium Alloys	1300 and below	704 and below	<1(4)
	Above 1300	Above 704	<0.1(4)
Copper Alloys(5)	Below 1000	Below 538	10 to 500
	1000 to 2100	538 to 1149	150 to 500

NOTES:
(1) For pressures higher than 100 microns, partial pressures of approved gases are required (see 3.3.1.1).
(2) For pressures higher than 20 microns, partial pressures of approved gases are required (see 3.3.1.1).
(3) Nitrogen not permitted as a partial pressure gas above 1400 °F (760 °C).
(4) Hydrogen not permitted as a partial pressure or quench gas.
(5) Alloys containing zinc - not recommended.
(6) For clarity, the single vacuum term “micron” is used. See 8.2.3 for relation to other values commonly used.
(7) The pressures specified apply to vacuum furnaces not equipped for atmosphere circulation.
(8) For furnaces equipped with atmosphere circulation, partial pressures higher than those indicated may be used at temperatures below 1000 °F (538 °C).
(9) At temperatures 2100 °F (1149 °C) and below, minimum pressure may be 1/10 of the value shown.

3.2.3 Vacuum Sensing Equipment

The vacuum furnace shall be equipped with at least one gauge capable of sensing and recording the pressure in the vacuum heating chamber of the furnace at any point within the equipment operating temperature range required for the material and processing being performed. Recommended gauges are shown in Table 3.

Table 3 - Vacuum level versus recommended gauge

Vacuum Level	Gauge
10^{-6} to 1 micron	Hot filament ionization
10^{-4} to 10 microns	Cold cathode ionization
1 to 10^{3} microns	Thermocouple or Pirani

3.2.3.1 Vacuum Measuring System Calibration

The vacuum system shall be compared against an independent vacuum measuring system that has been calibrated and is traceable to National Institute of Standards and Technology (NIST) or equivalent. The method of vacuum gauge calibration shall be by comparative method to validate the instrument, cables, and sensors as a complete system.

3.2.3.2 Frequency

The vacuum measurement system shall be calibrated at an interval that does not exceed 3 months. Calibration shall be conducted within the defined range of vacuum pressure used for production. Where the production vacuum pressure range is both above and below 1 micron, one calibration point shall be conducted at a single pressure reading above 1 micron and at a single pressure reading below 1 micron.

3.2.3.3 Accuracy Requirements

The required accuracy for vacuum pressures below 1 micron shall be ±0.5 decade.

Example: Vacuum gauge calibration accuracy for ±0.5 decade:

- Means an accuracy of the vacuum reading as times $10^{\pm 0.5}$
- Example: Test pressure value 5.0×10^{-4}
- Accuracy range would be $5.0 \times 10^{-4} * 10^{-0.5}$ to $5.0 * 10^{-4} * 10^{0.5}$
- $5.0 \times 10^{-4.5} = (5)(3.16 \times 10^{-5})$ to $5.0 \times 10^{-3.5} = (5.0)(3.16 \times 10^{-4})$
- ±0.5 decade = 1.6×10^{-4} to 1.6×10^{-3}

The required accuracy for vacuum pressures at or above 1 micron shall be as follows:

Vacuum pressures from 1 micron to atmosphere ±4 microns or ±40% of the actual reading, whichever is greater.

3.2.4 Heating Environment

3.2.4.1 Control of Heating Environment

3.2.4.1.1 Bake-Out Cycle

It is the responsibility of the processor to perform bake-out cycles to ensure that the heat treating furnace meet the contamination requirements of the applicable heat treating specifications. Bake-out cycles shall be carried out at not less than 50 °F (27 °C) above the maximum intended temperature for not less than 1 hour. The pressure shall reach at least a pressure equal to or below the intended operating pressure.

3.2.4.1.2 Leak Rate

Leak testing shall be performed weekly at ambient temperature. The leak rate shall not exceed the maximum permissible rate specified in Table 4 at a chamber pressure of 50 microns or lower. Initial leak rate shall be determined after closing the vessel and evacuation to 50 microns or lower. After reaching the initial evacuation level setpoint for the process being performed, all valves to the vessel chamber shall be closed, the initial pressure recorded, and a second reading of pressure made not less than 15 minutes after the first reading. If the vacuum level continues to go down or oscillates, it shall be considered a test failure. Leak rate is determined by dividing the rise in pressure (difference between final reading and initial reading) by the test time in hours. Leak rate is expressed as microns per hour. Surface contamination testing is not required if the leak rate test is successfully performed weekly unless the governing heat treatment specification requires more frequent testing for surface contamination.

3.2.4.1.2.1 As an alternative to the test of 3.2.4.1.2, vacuum furnaces that have an integral oil tank shall pass a surface contamination test in accordance with the following requirements:

3.2.4.1.2.1.1 Furnaces for heating steel parts above 1250 °F (677 °C), when less than 0.020 inch (0.51 mm) of metal is to be removed from any surface, shall be controlled to prevent carburization or nitriding and to prevent total decarburization.

3.2.4.1.2.1.2 Carbon and low-alloy steels heat treated to minimum tensile strength levels below 220 ksi (1517 MPa) shall meet the surface contamination requirements of AMS2759/1. Steels heat treated to minimum tensile strength levels of 220 ksi (1517 MPa) and higher shall meet the applicable surface contamination requirements of AMS2759/2.

3.2.4.1.2.1.3 Furnaces equipped with integral oil quench tanks shall not be permitted for processing titanium and titanium alloys above 1000 °F (538 °C), or for processing corrosion-resistant steels above 1100 °F (593 °C), unless appropriate tests such as a surface contamination tests as in 3.2.4.1.2.1.4 are conducted to ensure no detrimental surface effects are caused by such treatments.

3.2.4.1.2.1.4 Heat treated titanium and titanium alloy parts shall meet the applicable surface contamination requirements of AMS2801. For heat treat loads containing small parts (e.g., fastener components) such parts may be substituted for the coupons specified in AMS2801.

3.2.4.1.2.1.5 Heat treated precipitation hardening corrosion resistant and maraging steels shall meet the applicable surface contamination requirements of AMS2759/3. Austenitic corrosion resistant steels shall meet the applicable surface contamination requirements of AMS2759/4. Martensitic corrosion-resistant steels shall meet the applicable surface contamination requirements of AMS2759/5. Nickel and cobalt base alloys shall meet the applicable surface contamination requirements of AMS2773 and AMS2774.

3.2.4.1.2.1.6 Surface contamination tests shall be carried out at least weekly unless the referencing specification requires more frequent testing.

Table 4 - Maximum permissible leak rate for processing of various metals

Material	Leak Rate Microns/Hour
Carbon and Alloy Steels	50
Corrosion-Resistant Steels	
Ferritic (12 to 17% Cr)	50
Martensitic	50
Austenitic	50
Precipitation Hardening Steels	50
Superalloys	
Nickel Alloys	20
Cobalt Alloys	20
Iron Alloys	20
Tool Steels	
Air Hardening	50
Cold Work	50
Hot Work	50
High Speed (M Series)	50
High Speed (T Series)	50
Titanium and Titanium Alloys	10
Copper Alloys	50

3.3 Quenching Equipment

Furnaces used for quenching shall be equipped with cooling means sufficient for the material and process being performed.

3.3.1 Quenching Media

3.3.1.1 Gas Quench/Partial Pressure Gasses

The composition and dewpoint of the process gas upon delivery from the supply source shall be in accordance with the applicable requirements of CGA G-10.1, Grade L for nitrogen, CGA G-11.1, Grade C for argon, CGA G-9.1, Grade L for helium, and CGA G-5.3, Grade B for hydrogen as applicable.

3.3.1.1.1 Analysis of the dew point at the location of replenishment is not required, however, the dew point of the gas shall be -60 °F (-51 °C) or lower as the gas enters the furnace and shall be verified at least quarterly and also when the piping transmitting the gas is disturbed. In lieu of sampling the dew point at each furnace, the gas may be sampled at the end of each leg of supply piping, at the furthest point from the supply. All verifications of the gas dew point shall be performed using an instrument that is calibrated and traceable to NIST or equivalent. Each addition of gas to the system shall have been analyzed for purity by the producer and accompanied by a certificate of conformance upon delivery which shall be approved by the processor. Records of the review shall be maintained as quality records per the organization.

3.3.1.2 Oil Quench

Quench oil shall be compatible with the vacuum level used during initial evacuation and the quenching system shall be capable of quenching the parts at a rate sufficient to meet the specified property requirements.

3.4 Auxiliary Equipment

3.4.1 Fixture Materials

Shall be of adequate strength to support the parts being treated and shall not react with the material being treated. In particular, fixture/material combinations which readily form eutectics should be used with caution to avoid possible melting. Examples are provided in Table 5.

Table 5 - Eutectic temperatures for binary combinations

Binary Metal(1)(2)(3)(4)	Temperature °F	Temperature °C
Molybdenum/Nickel	2410	1321
Molybdenum/Platinum	3780	2082
Molybdenum/Carbon	4010	2210
Nickel/Carbon	2400	1316
Nickel/Tantalum	2410	1321
Nickel/Titanium	1730	943
Nickel/Iron	2620	1438

NOTES:

(1) Carbon (graphite) reacts with nickel alloys and corrosion-resistant steels to form eutectics melting as low as 2060 °F (1127 °C).

(2) Solid solutions and compounds may be formed by molybdenum in direct contact with alloys of nickel, chromium, and iron at temperatures as low as 2200 °F (1204 °C).

(3) Molybdenum forms continuous solid solutions with titanium and vanadium which reduce the melting point of molybdenum in relation to the percentage of the added element.

(4) Molybdenum forms solutions with platinum, rhodium, rhenium, and tungsten at temperatures over 2000 °F (1649 °C). Care should be taken where these materials may come in contact.

3.5 Procedure

3.5.1 Heat Treatment

Shall be in accordance with the referring specification.

3.5.2 Vacuum Level

Shall be as shown in Table 2. If pressures outside the specified ranges in Table 2 are used, tests shall be performed to demonstrate that alloy depletion/enrichment has not occurred. Pressures that drop below those specified in Table 2 during a heat treat cycle due to better vacuum levels attained with time shall not require testing of the load.

3.5.2.1 Outgassing

If the pressure rises during the heat-up cycle to a level such that either the partial pressure control level is exceeded and the gas used to maintain such pressure is no longer flowing, or the vacuum level needed to maintain diffusion pump operation is exceeded, the furnace shall be held at a constant temperature, or heating stopped, until the pressure drops to the acceptable level or other corrective action is taken.

3.5.2.2 Surface Discoloration

Any part discoloration shall be evaluated against the referenced heat treatment specification.

3.5.3 Load Sensors

One or more load sensors shall be used with each load with the exception noted in 3.5.3.3. The load sensor(s) shall be compatible with the material being processed or adequately sheathed to prevent reaction with the parts. The sensor(s) shall be located in the portions of the load which are predicted to be the last to attain the desired temperature. The sensor(s) may be attached to the outer surface of the parts. If a sensor is placed in a hole to measure the core or interior of the part or representation of parts being processed, the sensor shall make intimate contact with the surface at the bottom of the hole. To avoid errors due to conduction along the length of the sensor, the minimum depth of insertion of the sensor into the hole shall be at least ten times the diameter of the sensor.

3.5.3.1 In the event a sensor fails, the run need not to be aborted as long as another load sensor continues to record the correct temperature. If a second thermocouple is not in use, then the run shall be aborted unless failure occurs above the minimum of the allotted temperature range.

3.5.3.2 Once a load has been ran with load sensor(s), subsequent loads may be run without load sensor(s) provided that subsequent loads have an equal or fewer number of identical parts in the load and the distribution of the parts is the same as the distribution in the first load ran with load sensor(s). Records detailing the number of parts and distribution of parts from the first load ran with load sensors are required to be kept on file.

3.5.3.3 When use of load sensor(s) is impracticable, such as with multi-cell furnaces, tests shall be conducted to establish the correct heat-up time for the load.

3.5.3.3.1 The test shall incorporate load sensor(s) in the actual or simulated load to establish the correct heat up time for a given batch of parts. This procedure does not require quenching of the test load from the heat treatment temperature.

3.5.3.3.2 Once a load has been tested as in 3.5.3.3.1, subsequent loads may be run without load sensors(s), provided the subsequent loads have an equal or fewer number of identical parts in the loads, and the distribution of the parts is the same as that used in the test load. Records detailing the number of parts and distribution of parts from the test load are required to be kept on file.

3.5.3.4 Load sensors shall not be tack welded to parts without the approval of the cognizant engineering organization.

3.5.4 Fixturing and Racking

Parts shall be fixtured and racked to promote uniform heating and uniform circulation of the quenching media.

3.5.5 Protective Coating

Protective coatings may be used to prevent direct exposure of the part surfaces to the vacuum atmosphere provided they do not cause detrimental effects to parts. If coatings or plating are used, compensation for changes in part emissivity shall be made in the heating time. Additional heating time shall be determined by preproduction testing. When copper plating is used, pressure shall not be lower than 150 microns at temperatures above 1600 °F (871 °C).

3.5.5.1 Parts coated with copper plating or similar reflective coatings which reflect radiant heat shall have their soak time increased by at least 50% unless load sensors are used.

3.5.6 Cleaning

3.5.6.1 Prior to Heat Treatment

Parts, fixtures, and materials charged into the heating chamber shall be free of contaminants which might evaporate and react with the material being heat treated or the furnace components. Handling of cleaned parts and fixtures shall be such as to prevent contamination prior to charging into the furnace.

3.5.6.2 Post Heat Treatment

Shall be in accordance with referencing specification.

3.5.7 Quenching

3.5.7.1 Vacuum Cooling

Where there is a requirement for slow cooling, cooling performed under vacuum or partial pressure gas is permissible. Controlled cooling using a programmed heat input is permitted. When part temperature is specified, load sensor(s) shall be used to measure the actual load temperature during the cooling period.

3.5.7.2 Gas Quenching

When gas quenching is used, it shall be accomplished by backfilling the furnace with a gas that meets the requirements of 3.3.1.1. The system and the pressure of the backfill gas selected shall be capable of cooling the parts at a rate sufficient to meet the specified requirements.

3.5.7.2.1 Gas quenching shall be performed in accordance with the applicable requirements of the referencing specification for the materials listed therein.

3.5.7.3 Oil Quenching

Oil quenching shall be performed by transferring the parts from the heating chamber to a separate chamber which has been backfilled with the applicable gas according to the referencing specification and immersing the parts in a circulating oil.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

Unless otherwise specified by the cognizant quality assurance organization, the heat treatment processor shall be responsible for performance of all tests and inspections specified herein. The processor may use his own facilities or any commercial laboratory acceptable to the cognizant quality assurance organization. The purchaser reserves the right to perform any surveillance, tests, or inspection of parts and to review heat treatment records and results of processor's tests and inspections to verify that the heat treatment conformed to requirements of this specification.

4.2 Classification of Tests

4.2.1 Acceptance Tests

There are no acceptance tests.

4.2.2 Periodic Tests

Vacuum measuring system calibration (3.2.3.1), leak rate (3.2.4.1.2), and dew point (3.3.1.1.1) are periodic tests and shall be performed at the frequency specified herein.

4.2.3 Preproduction Tests

Vacuum measuring system calibration (3.2.3.1) and leak rate (3.2.4.1.2) are preproduction tests and shall be performed prior to any production heat treating on each piece of equipment (furnace) to be used.

4.3 Logs

Shall be in accordance with AMS2759.

4.4 Records

Shall be available to purchaser for not less than 5 years after heat treatment. The records shall contain all data necessary to verify conformance to the requirements of this specification.

4.5 Reports

Shall be in accordance with the referencing specification.

5. PREPARATION FOR DELIVERY

Shall be in accordance with the referencing specification.

6. ACKNOWLEDGMENT

Shall be in accordance with the referencing specification.

7. REJECTIONS

Parts that are not heat treated in accordance with the requirements of this specification, or with modifications not authorized by purchaser, will be subject to rejection.

8. NOTES

8.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

8.2 Definitions of terms used in AMS are presented in ARP1917 and as follows. The following list defines various terms commonly used in vacuum heat treating. These definitions are only presented to assist personnel not familiar with vacuum heat treatment. Some of the terms listed may not appear in the main body of the specification.

8.2.1 Leak Rate

A general indication of vacuum integrity of a system. The system is pumped into the high vacuum range, the pumping system is closed off, and the pressure rise over a given time of the closed system is observed. The rise will be the result of all sources of gas including outgassing of internal surfaces, virtual leaks, and any real leaks.

8.2.2 Partial Pressure

The actual pressure of any single gas component of a vacuum atmosphere. The total pressure is the sum of all of the partial pressures of the gaseous constituents of the atmosphere.