

LiMCA III Liquid Metal Cleanliness Analyzer

Inclusion analysis in liquid aluminum

Measurement made easy



Introduction

The LiMCA III uses the proven LiMCA measurement principle that is the industry benchmark for measuring non-metallic solid inclusions in molten aluminium.

It can be used under harsh industrial production conditions to provide an accurate indicator for the metal cleanliness of aluminium alloys.

The LiMCA III has a light measuring head with versatile and flexible positioning in molten metal.

Its lower center of gravity makes it very stable and easy to maneuver.

The LiMCA III has a laser level sensor that enables automatic raising and lowering of the measurement head to follow the level of the molten metal during a cast

Features

- On-line real time inclusion measurement
- Number and size of inclusions
- Measurement at any point along the process
- AC modulation eliminates use of batteries
- Readings not affected by electromagnetic noise of casting environment
- Standard web based HMI will run on most computers and tablets
- Self-contained analyzer; dedicated server not required

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The Company

We are an established world force in the design and manufacture of measurement products for industrial process control, flow measurement, gas and liquid analysis and environmental applications.

As a part of ABB, a world leader in process automation technology, we offer customers application expertise, service and support worldwide.

We are committed to teamwork, high quality manufacturing, advanced technology and unrivalled service and support.

The quality, accuracy and performance of the Company's products result from over 100 years experience, combined with a continuous program of innovative design and development to incorporate the latest technology.

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1 About this manual

1.1 Purpose of document

This document is intended for personnel using the LiMCA III for routine analysis and contains installation, user and troubleshooting instructions.

Read this manual carefully before working with the product. For personal and system safety and for optimum performance, make sure you thoroughly understand the contents before installing, using or maintaining this instrument.



All servicing of the equipment is to be performed by Qualified ABB Service Personnel only.



No user/operator adjustments inside the LiMCA III are necessary or recommended by the manufacturer.

1.2 Definition of icons

This publication includes Warning, Caution, and Information where appropriate to point out safety-related or other important information. It also includes Tip to point out useful hints to the reader. The corresponding symbols should be interpreted as follows:



DANGER – Serious damage to health / risk to life

The electrical warning symbol indicates the presence of a potential hazard which could result in electrical shock.



WARNING – Bodily injury

The electrical warning symbol indicates the presence of a potential hazard which could result in electrical shock.



DANGER – Serious damage to health / risk to life

The ISO General Warning symbol indicates safety information that must be followed by the user. The information concerns the presence of a potential hazard which could or may result in personal injury or even death.



WARNING – Bodily injury

The ISO General Warning symbol indicates safety information that must be followed by the user. The information concerns the presence of a potential hazard which could or may result in personal injury or even death.



WARNING – Property damage

This message indicates a potentially damaging situation. Failure to avoid this could result in damage to the product or its surrounding area.



DANGER – Laser radiation

The laser warning icon indicates the presence of a hazard related to the presence of a laser.



DANGER – Hot Surface

Potential burn hazard.



DANGER – Crush hazard

The sharp surface warning symbol indicates the presence of a sharp surface of object that could result in personal injury if touched.



Caution – Minor injuries

This message indicates a potentially dangerous situation. Failure to avoid this could result in minor injuries. This may also be used for property damage warnings.



Attention - Important information

This symbol indicates particularly useful information, or important information about the product or its further uses. The signal word "IMPORTANT (NOTE)" does not indicate a dangerous or harmful situation.



Helpful tip

This symbol indicates operator tips about the product or its further uses.



Attention - Electrostatic Discharge

The ESD symbol indicates the presence of equipment sensitive to electrostatic discharge.



Attention - Location of Ground

The Ground symbols is used to identify protective earth conductor terminals.

2 Safety

2.1 General safety information

The “Safety” section provides an overview of the safety aspects to be observed for operation of the device.

The device has been constructed in accordance with the state of the art and is operationally safe. It has been tested and left the factory in perfect working conditions. The information in the manual, as well as the applicable documentation and certificates, must be observed and followed in order to maintain this condition throughout the period of operation.

Full compliance with the general safety requirements must be observed during operation of the device. In addition to the general information, the individual sections in the manual contain descriptions of processes or procedural instructions with specific safety information.

Only by observing all of the safety information can you reduce to the minimum the risk of hazards for personnel and/or environment. These instructions are intended as an overview and do not contain detailed information on all available models or every conceivable event that may occur during setup, operation, and maintenance work.

For additional information, or in the event of specific problems not covered in detail by these operating instructions, please contact the manufacturer. In addition, ABB declares that the contents of this manual are not part of any prior or existing agreements, commitments, or legal relationships; nor are they intended to amend these.

All obligations of ABB arise from the conditions of the relevant sales agreement, which also contains the solely binding warranty regulations in full. These contractual warranty provisions are neither extended nor limited by the information provided in this manual.



Caution – Minor injuries

Only qualified and authorized specialist personnel should be charged with installation, electrical connection, commissioning, and maintenance of the LiMCA III. Qualified personnel are persons who have experience in installation, electrical wiring connection, commissioning, and operation of the LiMCA III or similar devices, and hold the necessary qualifications such as:

- Training or instruction, i.e., authorization to operate and maintain devices or systems according to safety engineering standards for electrical circuits, high pressures, and aggressive media
- Training or instruction in accordance with safety engineering standards regarding maintenance and use of adequate safety systems.

In addition, you must observe the relevant plant safety regulations and national standards regarding the installation and operation of electrical systems.



WARNING – Bodily injury

The device is operated at extremely high temperature in liquid aluminum. As a result, serious injury or significant property damage may occur if this device is operated incorrectly.

2.2 Class of equipment

The LiMCA III analyzer has an exposed metal chassis that is connected directly to earth via a power supply cord and is therefore classified as Safety Class I equipment according to IEC 61010-1.

A power cord without a connector is supplied with the instrument. The user has to provide the mains connector as per plant and country regulations. Note that the equipment calls for a lockable connector.



DANGER – Serious damage to health / risk to life

To avoid electrical shock, do not operate this equipment if it bears any sign of damage to any portion of its exterior surface.

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2.3 Fuse type

The LiMCA III analyzer has no main power fuses as breakers are used. The main power breakers are rated as follow:

Breaker type (100-240 VAC) 5A, 2 poles, Tripping curve K (according to IEC/EN 60947-2)

2.4 Power connection

In accordance with international safety standards, the LiMCA III Unit uses a three-wire power supply cord. When connected to an appropriate AC power receptacle, this cable grounds the equipment chassis. A power supply cord that is appropriate for the destination country is supplied with each LiMCA III Unit and Dolly.



DANGER – Serious damage to health / risk to life

To avoid risk of injury or death, ALWAYS observe the following precautions before operating the LiMCA III Unit and/or Dolly.

- Use only a power supply cord with a protective Earthing terminal.
- Connect the power supply cord only to a power outlet equipped with a protective Earth contact. Never connect to an extension cord that is not equipped with this feature.
- Willfully interrupting the protective Earth connection is prohibited.

2.5 Improper use

It is prohibited to use the device for the following purposes:

- As a climbing aid, e.g., for mounting purposes.
- As a support for external loads, e.g., as a support for pipes.
- Adding material, e.g., by painting over the name plate or welding/soldering on parts.
- Removing material, e.g., by drilling the housing.

Repairs, alterations, and enhancements, or the installation of replacement parts, are only permissible as far as these are described in the manual. Approval by ABB must be requested for any activities beyond this scope. Repairs performed by ABB-authorized centers are excluded from this.

2.6 Technical limit values

The device is designed for use exclusively within the values stated on the name plates and within the technical limit values specified on the data sheets.

The following technical limit values must be observed:

- The Maximum Working Pressure must not be exceeded.
- The Maximum ambient operating temperature shall not be exceeded.
- The Maximum process temperature must not be exceeded.
- The housing protection type must be observed.

2.7 Warranty prevision

Using the device in a manner that does not fall within the scope of its intended use, disregarding this manual, using underqualified personnel, or making unauthorized alterations, releases the manufacturer from any liability for any resulting damage. This makes the manufacturer's warranty null and void.

2.8 Operator liability

The operators must strictly observe the applicable national regulations with regard to installation, function tests, repairs, and maintenance of electrical devices.

2.9 Qualified personnel

Installation, commissioning, and maintenance of the device may only be performed by trained specialist personnel who have been authorized by ABB. The specialist personnel must have read and understood the manual and comply with its instructions.



WARNING – Property damage

Read this manual thoroughly before using this equipment. If you do not understand the content of this manual, contact ABB service personnel.

2.10 Returning devices

Use the original packaging or suitably secured shipping package if you need to return the device for repair or recalibration purposes.

According to EC guidelines and other local laws for hazardous materials, the owner of hazardous waste is responsible for its disposal. The owner must observe the proper regulations for shipping purposes.

All devices sent back to ABB must be free from any hazardous materials (acids, alkalis, solvents, etc.).

2.11 Disposal

ABB actively promotes environmental awareness and has an

operational management system that meets the requirements of ISO 9001:2008 and ISO 14001:2004. Our products and solutions are intended to have minimum impact on the environment and persons during manufacturing, storage, transport, use and disposal.

This includes the environmentally friendly use of natural resources. ABB conducts an open dialog with the public through its publications.

This product/solution is manufactured from materials that can be reused by specialist recycling companies.

2.12 Information on WEEE Directive 2002/96/EC (Waste Electrical and Electronic Equipment)

This product or solution is subject to the WEEE Directive 2002/96/EC or corresponding national laws (e.g., the ElektroG - Electrical and Electronic Equipment Act - in Germany)/

According to the EU Directive 2012/19/EU on Waste Electrical and Electronic Equipment (also known as WEEE II), only products used in private applications may be disposed of at municipal garbage facilities. Proper disposal prevents negative effects on people and the environment, and supports the reuse of valuable raw materials.

Make sure that at the end of life the LiMCA III is properly disposed of according to corresponding procedure.

2.13 Transport and storage

- After unpacking the LiMCA III, check the device for transport damage.
- Check the packaging material for accessories.
- During intermediate storage or transport, store the LiMCA III in the original packaging only.

The instrument does not require any special treatment if stored as dispatched and within the specified ambient conditions. There is no limit to the storage period, although the terms of guarantee remain as agreed with the Company and as given in the order acknowledgement.

2.14 Safety information for inspection and maintenance



DANGER – Serious damage to health / risk to life

There is no EMC protection or protection against accidental contact when the housing cover is open. There are electric circuits within the housing which are dangerous if touched. Therefore, the power cord must be removed from the power outlet before opening the housing cover.



DANGER – Serious damage to health / risk to life

The device can be operated at high pressure and with aggressive media. Any process media released may cause severe injuries.

Corrective maintenance work may only be performed by trained personnel.

- Check whether hazardous materials have been used as materials to be measured before opening the device. Residual amounts of hazardous substances may still be present in the device and could escape when the device is opened.
- Within the scope of operator responsibility, check the following as part of a regular inspection:
 - Measurement-related function
 - Wear (corrosion)

2.15 Laser

The LiMCA III analyzer incorporates a laser system used to measure the vertical position of the analyzer relative to the molten metal surface. The laser device is located on the left side of the instrument head. The laser beam points downward vertically.

2.15.1 Laser specifications

The following table gives the specifications of the laser used in the LiMCA III analyzer.

Table 1: Laser specifications

Laser classification	Class 2 (IEC) / Class II (FDA)
Laser power	560 µW
Laser light source wavelength	655 nm
Laser light source	visible red light
Laser measuring range	200-1000 mm
Laser measuring resolution	0.3 mm

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2.15.2 Laser warning

The LiMCA III uses a class 2 laser during normal operation.



Class 2 Laser Product
Visible laser radiation at 655 nm, 560 μm .
Do not stare into beam.

2.16 Electrical warnings



Ensure that the equipment and any devices or power cords connected to the LiMCA III are properly grounded.



Protective earthing connection (grounding) must be active at all times. The absence of grounding can lead to a potential shock hazard that could result in serious personnel injury. If an interruption of the protective earthing connection is suspected, ensure the equipment is not used.

Use the LiMCA III ONLY if a properly grounded power outlet is available.

Before using the LiMCA III, make sure the appropriate line voltage is available.

Use a power extension ONLY if it has proper conductive protection (grounding).

2.17 2.5 Conformity declaration and certificates

ABB LiMCA III have the following conformity certifications:

- CE marking (including LVD, EMC, ROHS, WEEE, Machinery Dir.);
- CB scheme (IECEE) for electrical safety;
- NRTL marking for electrical safety (e.g. CSA, TUV or NEMKO for CAN & USA)
- Laser safety / FDA markings & registration

2.18 Labels

ABB Inc.
3400, Rue Pierre-Ardouin
Québec, QC, G1P 0B2
Canada
Phone : (418) 877-2944
www.abb.com/analytical

MODEL:
SERIAL NO.:
MANUFACTURE DATE:

CE FC MARKING PENDING PATENT PENDING BREVET EN INSTANCE
MADE IN CANADA FABRIQUÉ AU CANADA

CLASS 2 LASER PRODUCT
Visible laser radiation
655nm, 560µW

MARKING PENDING
LASER COMPLIES WITH FDA RADIATION PERFORMANCE STANDARDS:
21 CFR CHAPT. 1 SUBCHAPT J.
AND IEC 60825-1:2007

WARNING:
TO AVOID ELECTRICAL SHOCK, THE POWER CORD PROTECTIVE CONDUCTOR MUST BE CONNECTED TO EARTH. TO PREVENT TIPOVER OF THE INSTRUMENT, USE THE STABILIZER BARS ACCORDING TO THE USER MANUAL. USE ONLY THE SUPPLIED LIFTING KIT TO LIFT THE INSTRUMENT BY CRANE. MOVING PARTS CAN CRUSH OR CUT. STAY CLEAR OF THE MOVING MECHANISM.

AVERTISSEMENT :
POUR PRÉVENIR LES CHOCS ÉLECTRIQUES, LE CONDUCTEUR DE MASSE DOIT ÊTRE RELIÉ À LA TERRE. POUR PRÉVENIR LES RISQUES DE RENVERSEMENT, UTILISER LES BARRES STABILISATRICES SELON LE GUIDE DE L'USAGER. LEVER SEULEMENT L'INSTRUMENT EN UTILISANT L'ENSEMBLE DE LEVAGE FOURNI. LES PIÈCES MOBILES PEUVENT ÉCRASER OU COUPER. FAIRE ATTENTION LORSQUE LE MÉCANISME EST EN MOUVEMENT.

CONNECTORS ADDITIONAL INFO:

POWER: OFF/ON
ETHERNET: IP:
EXTERNAL ALARM
VORTEX
POWER INLET: 100-240 VAC, 47-63 Hz, 600 VA

ARGON INPUT: Flow rate: 0.5 SCFM nominal, Pressure rate: 60 Psig min., 100 Psig max.
DRY AIR INPUT: USE DRY OIL-FREE AIR ONLY. UTILISER DE L'AIR SEC, SANS HUILE. Flow rate: 30 SCFM nominal, Pressure rate: 70 Psig min., 145 Psig max., Temperature: < 35 °C

Figure 1: Name Plate



Figure 2: LiMCA III, Class 1 Laser Safety Label



Figure 3: LiMCA III handling label



Figure 4: LiMCA III tip over hazard label



Figure 5: Pinch points warning label



Figure 6: Moving parts, possible crushing warning label

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3 Introduction

3.1 Overview

The LiMCA III system is designed to measure the concentration and size distribution of non-conductive particles in suspension in molten aluminum.

The LiMCA III system provides granulometric and total density information on the inclusion content of aluminum melts, in real time, based on an objective and user independent method. It is ideally suited for applications in process development, process control, and quality assurance.

The LiMCA III system can characterize the cleanliness of a melt at time intervals of the order of 1 minute. It can therefore monitor quasi-continuously, and in real time, the evolution of cleanliness along a cast, as a function of process parameters and melthandling practices, or merely as a function of time. The impact of furnace preparation, alloying practice, feedstock mix, settling time, and similar parameters on melt cleanliness, is easily determined.

3.2 Process development and optimization

The effects of routine casting practices-metal level control, turbulence in the metal distributor-can be observed directly as they take place. The time at which inclusion flushing from the holder starts at the end of a cast, can be determined for different sets of casting parameters, enabling the metallurgist to stop the cast at the right time to minimize the need for heel removal.

New melt-handling or treatment equipment can be closely monitored and optimized from a cleanliness standpoint at the time of commissioning. The operation parameters of inline melt treatment equipment-e.g. gas flow rates and mixes in filter-degassers-can be optimized to meet quality requirements at minimum cost. The performance of ceramic foam filters, or bed filters-can be objectively determined by running measurements upstream and downstream of the equipment. The optimal replacement frequency of CFFs and of beds can be established on the basis of sound data.

3.3 Applications

3.3.1 Process control

Once the cleanliness of a melt as a function of key casting parameters has been established, the stability of

the process can be verified periodically on the basis of established SPC (statistical process control) methods. The ease of operation of the system means that it can be used around the clock by production personnel. Data are archived on the disk of the computer, along with several cast parameters, such as date and time, casting site and furnace unit, alloy identification, and key casting practices. These data can be stored in standard spreadsheet format, making them easy to import into various SPC programs.

3.3.2 Quality assurance.

The immediate availability of the data, and its objective character, are ideal for ensuring the suitability of a melt for the casting of a product with known cleanliness requirements. The verification can be done at the outlet of the furnace (in the case of in-furnace melt treatment), or at the outlet of filters (in the case of in-line treatment). If the melt does not meet the requirements, the metallurgist can elect to abort the cast to minimize the risk of having to recycle a rejected product.

LiMCA melt quality certificates can become part of a standard quality assurance program. They can provide critical documentation for use in cases of customer complaint. In addition, the commitment to perform melt cleanliness verification with LiMCA can be made part of a supply contract to a customer with high quality requirements, thus providing a critical marketing advantage over less well-equipped competitors.

3.3.3 Automatic functions

The Automatic Functions are integrated hardware and software features of the LiMCA III instrument. These features allow the instrument to operate and generate validated particle size distribution data with minimum assistance of the operator. The LiMCA III Automatic functions are listed in "Table 2: LiMCA III Automatic functions" on page 13.

Table 2: LiMCA III Automatic functions

	Automatic LiMCA III functions
Positioning	<ul style="list-style-type: none"> • Automatic probe immersion sequence • Metal level tracking • Automatic probe withdrawal sequence • Emergency probe withdrawal upon probe maximum immersion detection
Corrective actions	<ul style="list-style-type: none"> • Rapid pressure/vacuum cycles during first immersion upon orifice blockage diagnostic • Automatic conditioning upon detection of increased hole resistance • Automatic conditioning when cycle exceeds normal length • Operator assistance request as a last resort (ex: to replace a broken probe)
Data validation	<ul style="list-style-type: none"> • Up/down ratio above a maximum value • Sample size below a minimum volume • Initial filter release

With little training and the LiMCA III Automatic functions, a cast operator only needs to bring the instrument to its measurement location and insert a probe. Then, when metal flows in the through, he starts an automated measurement to initiate the immersion sequence. The operator can then leave the instrument do its work.

The LiMCA III instrument moves its head down until it senses the metal, preheats the probe, immerses it to the preset tracking position, starts a measurement cycle, acquires and validates data points and takes corrective actions when needed if tracking mode is on. At all times during the trial, the positioning system senses the head position variations relative to the liquid metal surface and adjusts it to maintain the degree of immersion of the probe. The system requests assistance of an operator only if it cannot solve a problem by itself.

Shortly before the end of the cast, an operator only has to stop the sequence to initiate the withdrawal sequence. The data acquisition is then stopped, the probe emptied and safely withdrawn from the melt to be removed by the operator.

3.4 Theory of operation

The name LiMCA stands for Liquid Metal Cleanliness Analyzer. The technique is based on the principle of the resistive pulse / electric sensing zone technique (ESZ). The LiMCA III system measures the total concentration and the

granulometry of dielectric inclusions in suspension in molten aluminum and aluminum alloys.

The basic LiMCA instrument is illustrated in “Figure 7: LiMCA III operation schematic” on page 13. It is made up of a closed tube with a small orifice that is positioned in a larger container of liquid metal. The metal with the suspended particles to be detected is made to flow through the small orifice by creating a vacuum inside the tube. The tube is made of electrically insulating material. There are two types electrodes: one in-probe electrode located inside the tube, and 4 external electrodes. All electrodes are immersed in the liquid metal. A alternate electrical current is applied between the in-probe and the external electrodes, and flows through the liquid metal in the small orifice of the tube. the presence of a particle in the liquid flow, when going through the orifice, modifies the electrical resistance detected at the orifice.

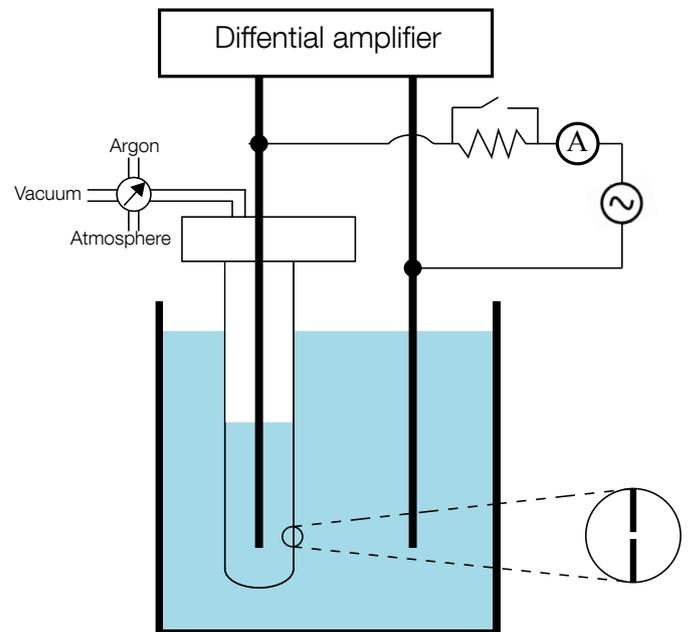


Figure 7: LiMCA III operation schematic

When a particle enters the orifice, it displaces its volume of the conducting fluid, causing a temporary rise in the electrical resistance of the orifice. This resistance change, in the presence of the applied current, causes a voltage pulse of duration approximately equal to the transit time of the particle to appear across the orifice. The electrical potential produced by the constant current varies in relation to the change in

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resistance each time a particle goes through the orifice. A detection circuit determines the size of the particle from the change in voltage caused by its presence. The magnitude of the change depends on the volume of the particle. A difference in voltage due to the passage of a particle takes the form of a pulse ("Figure 8: Resistive pulse principle of particle size measurement" on page 14) on the reference line. The reference line corresponds to the voltage created by the constant current going through the circuit consisting of the electrodes and the liquid metal when no inclusions are present.

The amplitude of the signal caused by particles of a size likely to be encountered in molten aluminum (10 μm to 100 μm) is quite small. The amplitude varies from only 2 μV up to 2000 μV , making highly-sensitive measuring equipment mandatory.

$$\Delta V = \frac{4\rho Id^3}{\pi D^4}$$

Where: ΔV = variation of voltage at the orifice
 ρ = resistivity of the metal (Al = $25 \times 10^{-8} \Omega\text{m}$)
 d = diameter of the equivalent spherical particle
 D = diameter of the cylindrical sensing zone
 π = constant 3.1416
 I = current (typically 40 A)

To sum up, the process provides a method for detecting particles in suspension that are larger than a predetermined size (20 μm) and whose electrical conductivity differs from that of the molten metal. It requires:

- that the tube submerged in the molten metal be constituted of a material that resists the mechanical, thermal, and chemical strains imposed by molten aluminum;
- that electrodes be placed inside and outside the insulating tube so that a constant electrical current can be established between the electrodes, through the flow of molten metal that goes through the orifice;
- that a pneumatic system creates a difference in pressure between the inside and the outside of the tube, to force the liquid metal through the orifice, while maintaining the electrical current between the electrodes;
- that a sensitive electronic system measures the small voltage variations at the electrodes caused by the passage of suspended particles through the orifice in the tube;
- that an electronic system counts the number of voltage variations at the electrodes and measure their intensities, which are representative of the size of the particles causing the variations.

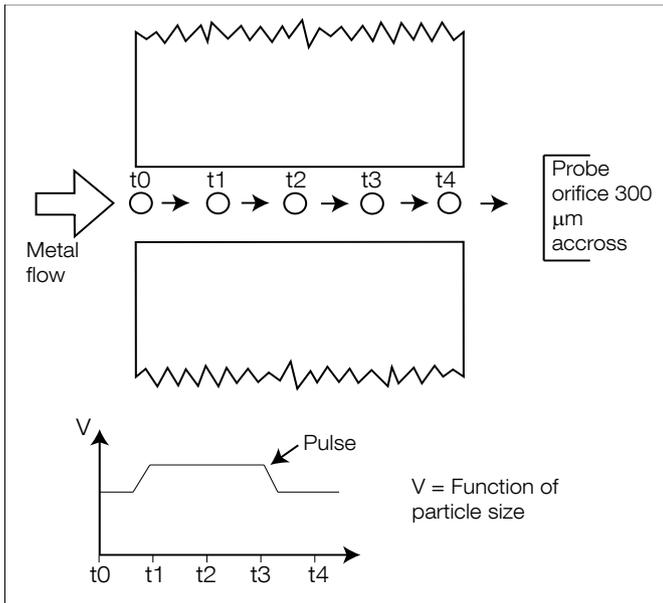


Figure 8: Resistive pulse principle of particle size measurement

The magnitude of the voltage pulse (height from the reference line to the pulse peak) is related to the diameter of the equivalent spherical particle, according to R.W. Deblois and C.I. Bean,¹ by the following equation:

¹ R.W. Deblois and C.P. Bean, Counting and sizing in of sub-micron particles by the resistive pulse technique, Rev. Sci. Instr. Vol. 41, No. 7, 1970, p. 909-915

3.5 LiMCA III main components

The LiMCA III analyzer consists of the LiMCA III instrument itself, and the dolly (see “Figure 9: The LiMCA III analyzer” on page 15).



Figure 9: The LiMCA III analyzer

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3.5.1 LiMCA III instrument

The instrument consists of a head, a flexible, hinged neck, and a main body. The head holds the probes and the electrodes, generates the pressure required to force molten metal into and out of the probe, and contains signal-producing electronics. The main body contains the direct current generation circuit, data-processing electronics, a cooling apparatus (for maintaining an acceptable temperature in a hot environment), DC power supplies, and connections for interfacing both with external supplies and with a computer. The body also includes an electronic actuator to lower and raise the head into and out of the melt.

3.5.2 The sensing head

The probes of the sensing head are illustrated in “Figure 19: Consumable parts in contact with the melt” on page 24. The glass sampling probe, the main consumable, has the orifice through which the metal flows.

The head has five Tungsten electrodes. The five current electrodes carry the AC current that turns the orifice in an electric sensing zone. The positioning system is provided by the laser.

The head has three thermocouples. The function of the metal thermocouple is to detect when the sampling probe is full. The safety thermocouple, as its name indicates, is there to protect the mandrel. The maximum immersion thermocouple is also a safety feature. It detects when the head moves down too deeply in the metal.

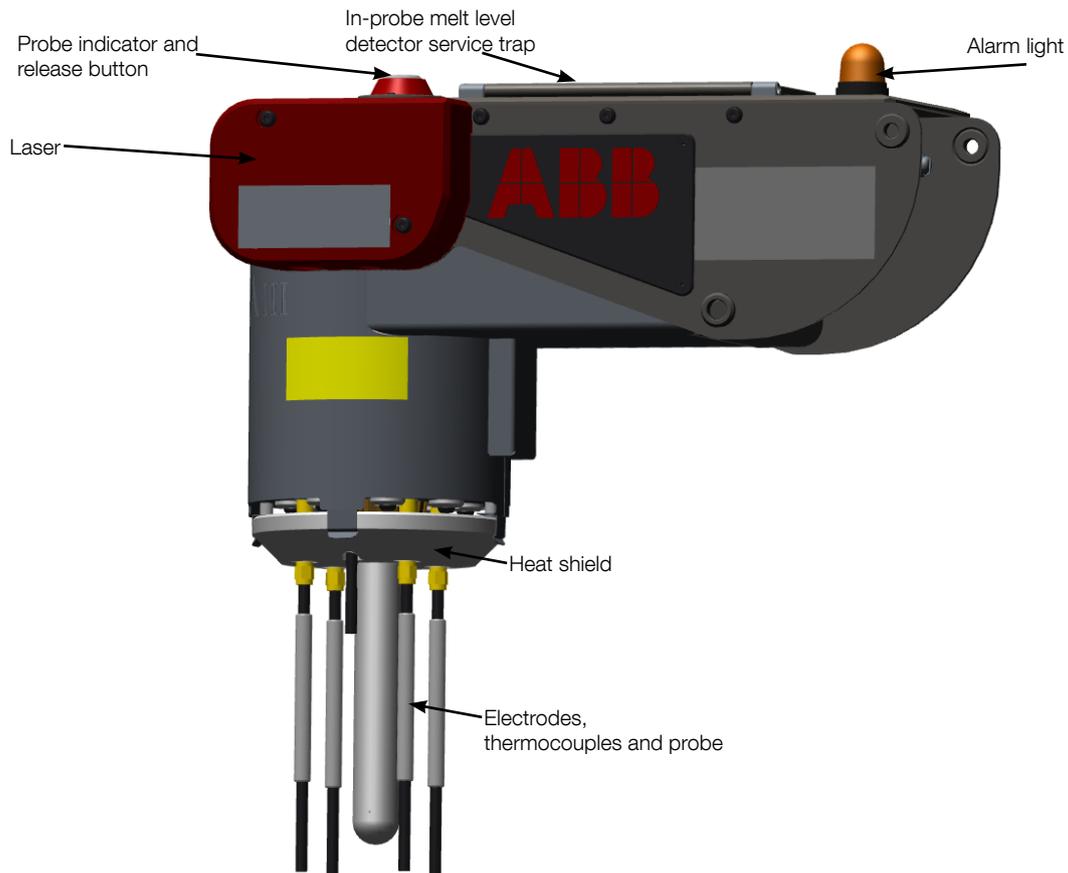


Figure 10: The LiMCA III head

3.5.3 LiMCA III dolly

The main body is supported by a wheeled cart or dolly which is used both as a platform from which measurements are run, and as a means of moving the instrument around. It can be maneuvered by one person. Manual positioning mechanism with a crank can raise and lower the head. It should be easy to operate the crank. The entire unit can thus be adapted to various launder shapes and other plant particularities.

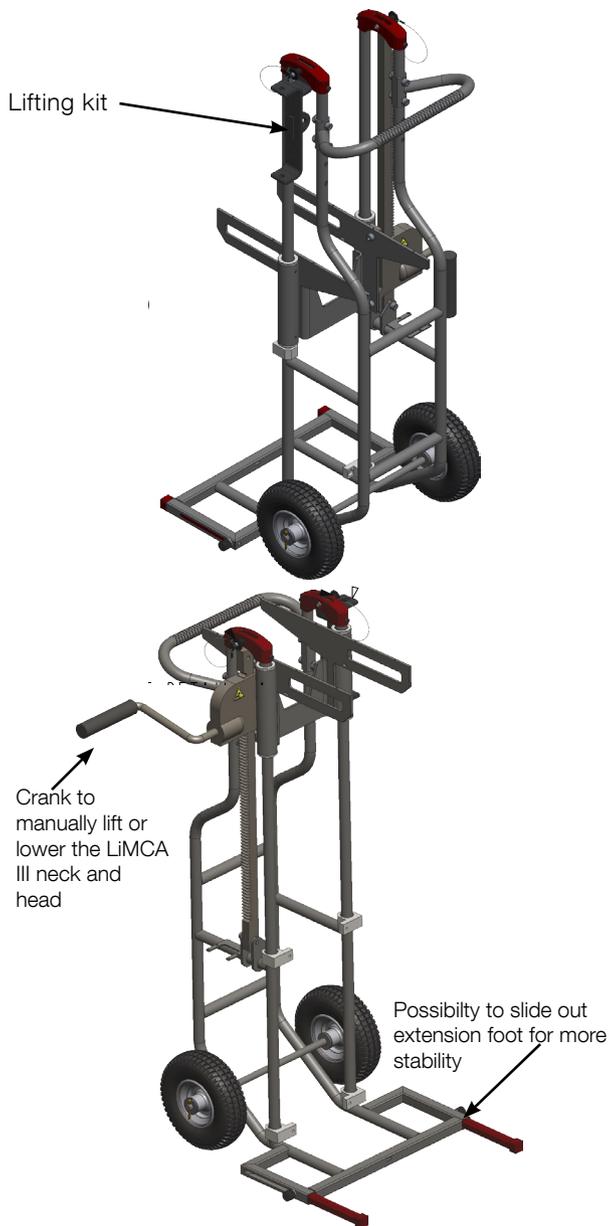


Figure 11: The LiMCA III dolly

3.5.4 LiMCA III neck

The LiMCA III neck with its positioning system allows vertical and horizontal movement to position the LiMCA III head above the trough for measurement. Once the proper height achieved with the dolly's crank, the LiMCA III neck and head can be pushed forward on the sliding rails to position the head. To lower the head into the melt, the motorized positioning system is used by means of the knob located on the manual control panel on the left side of the instrument.

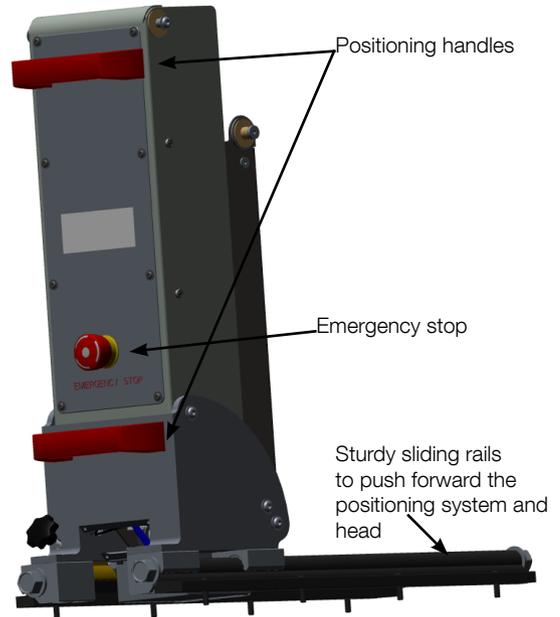


Figure 12: The LiMCA III neck

3.5.5 Cable carrier

The cable carrier contains all the hoses and cables that connect the main body to the neck/head and that allow the instrument to operate: compressed air, argon, electricity and data link.

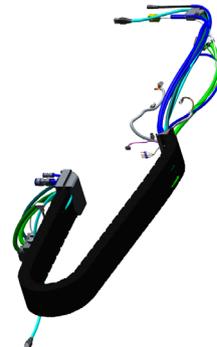


Figure 13: The LiMCA III cable carrier

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3.5.6 Main body

The main body contains all the modules and parts to coordinate, to process and to stock the measurement:

- Inside, all power, electronic and pneumatic controls of the instrument are accessible through the front panel, and should only be opened for servicing.

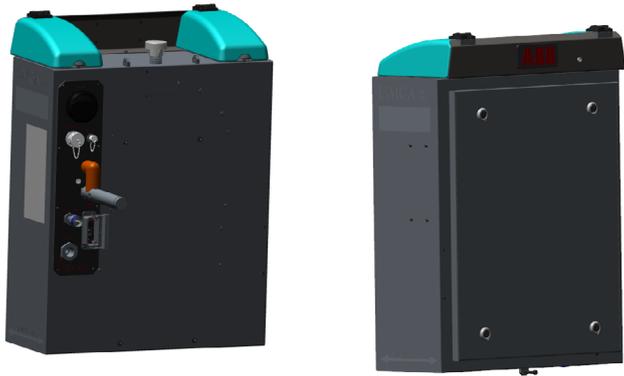
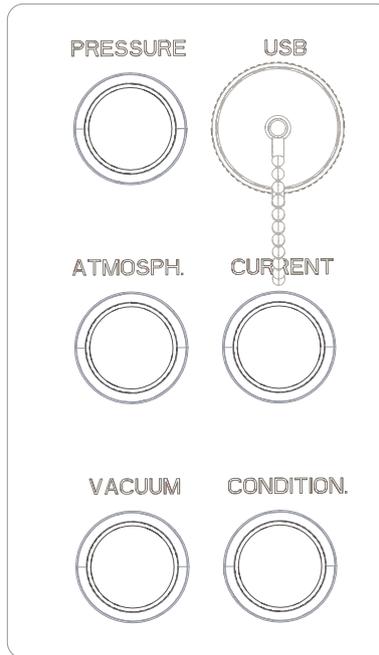


Figure 14: Main body back (left) and front (right)



Button to apply pressure to push the metal out the probe

USB connector to connect a USB key (software update for example)

Button to apply atmosphere

Button to apply current between the electrodes

Button to apply vacuum in the probe to force the aluminum through the orifice into the probe

Button to perform conditioning in order to clean the probe orifice

Figure 16: Manual controls right

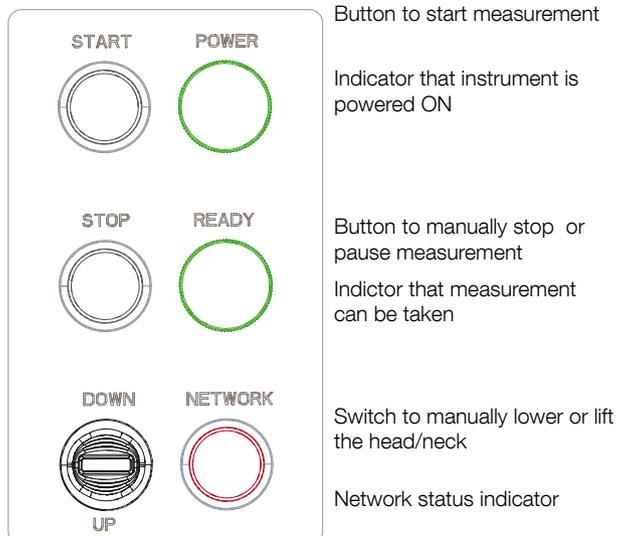


WARNING – Property damage

The front panel is to be opened by ABB service personnel for maintenance or service only.

3.5.6.1 Analyzer manual control

The manual control panel of the LiMCA III analyzer provides manual control and status indicators. It is located on top of the main body on the right and left.



Button to start measurement

Indicator that instrument is powered ON

Button to manually stop or pause measurement

Indicator that measurement can be taken

Switch to manually lower or lift the head/neck

Network status indicator

Figure 15: Manual controls left



Attention - Important information

The USB connector is used only by ABB service personnel. Always keep the associated cover on the connector from the environment.

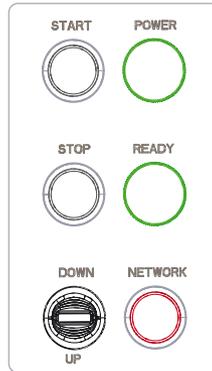
The manual controls allow to manually control two functions of the LiMCA III system:

1. Apply fine positioning of the sensing head
2. Apply pressure or vacuum in the sampling probe.
3. 3. apply current
4. 4. put high current conditioning.

The manual controls are designed to facilitate operations near the metal at the start-up and at the end of measurements.

The buttons and LEDs are described in detail in below table.

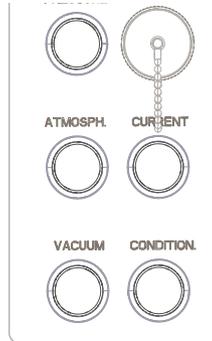
3.5.8.1 Leds and button details



LED or Button	No colour (no light)	Solid white, solid red or green	Flashing
START	 Instrument is OFF or not ready for measurement	 When the start functionality is available (in ready, pause or terminating state), the light is ON. Press START to take a measurement	 When the instrument is in an automatic sequence and Start is pressed, the light is flashing.
POWER	 Instrument is not powered.	 Instrument is powered	N/A
STOP	 If the light is OFF, the functionality is not available: for example, the instrument is not at ready state.	 If the light is ON, the functionality is available. The stop button puts the instrument into pause state. If a second stop is performed (while in pause state), the instrument terminates its acquisition, lift the head to its initial position and returns to ready state.	 The light will flash when the acquisition is terminated.
READY	 The instrument is not ready for measurement, either not powered or modules are not yet ready for measurement	 All instrument modules are ready and probe is grabbed.	
UP/DOWN	 (No text description for this row)	Use UP/DOWN knob to manually lower or lift the LiMCA III head and neck when it is already above the trough.	
NETWORK	 If the light is OFF, remote connection is not available.	 If the light is ON, the remote connection is available.	 If the light flashes when the instrument is remotely accessed.

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LED or Button	No colour (no light)	Solid white, solid red or green	Flashing
			
PRESSURE	Instrument is OFF or not ready for measurement	Light is ON when the functionality PRESSURE is available. In manual mode, the pressure button applies pressure inside the probe to force metal outside of the probe.	The light flashes when pressure has been applied (either by the user in manual mode or in automatic sequence).
USB		The USB connector is used to upgrade software or retrieve IP address.	
ATHMOSPHERE	Instrument is OFF	Light is ON when the functionality ATHMOSPHERE is available. In manual mode, the atmosphere button puts the probe to atmosphere pressure. The metal will stay at the same level in the probe.	The light flashes when the atmosphere has been applied (either by the user in manual mode or in automatic sequence).
CURRENT	Instrument is OFF or not ready for measurement	Light is ON when the functionality CURRENT is available. In manual mode (and if all modules are ready), the current button will put the current ON. To stop the current, the user must press on CURRENT button again.	When the current is applied (by the user either in manual mode or in automatic sequence), then the light will flash. Press current to manually apply current between the electrodes.
VACUUM	Instrument is OFF or not ready for measurement	Light is ON when in manual mode the functionality CURRENT is available. In manual mode, the vacuum button will put the probe into vacuum conditions to draw metal inside the probe.	When the vacuum is applied (either by the user in manual mode or in automatic sequence), then the light will flash. In Manual Mode when applying vacuum, the in-probe melt level detector is not activated. Make sure to have a direct contact with the metal level inside the probe to manually put the instrument to atmosphere or pressure
CONDITIONING	Instrument is OFF or not ready for measurement.	Light is ON when the functionality CONDITIONING is available. In manual mode, the conditioning button will generate a high voltage to clean the probe hole.	Conditioning has been manually applied (either by the user in manual mode or in automatic sequence).
Probe	No probe is detected in the probe support.	A probe has been detected and is grabbed by the support.	If the light flashes, then the probe is being ejected.

3.5.6.2 Simplified operation sequence diagram

The simplified operation sequence illustrates the different steps of the LiMCA III operation, as the booting sequence, measurement preparation, measurement and terminating.

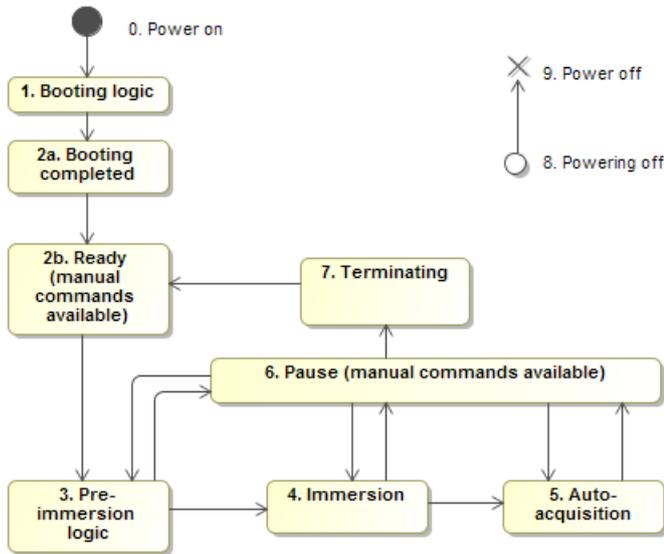


Figure 17: Simplified operation sequence diagram

3.5.6.3 LiMCA III interface panel

All connections that are necessary to operate the LiMCA III instrument are located on the LiMCA III interface panel and comprise the main power on switch, the Ethernet connector, an External alarm connector, cooling, argon and compressed air supply, and the main power connector. Refer to “Figure 24: Analyzer connection panel” on page 28.

3.5.6.4 Main body front access panel

All connections are to be done on the interface panel. The main body front access panel should only be opened for maintenance.

3.5.7 LiMCA III software interface

The LiMCA III user interface is designed as a series of simple web pages that can be accessed through most web browsers, recommended are Firefox® or Chrome™. The web browser interface allows viewing the current status of the LiMCA III and setting configurable parameters.

The LiMCA III does not require to be connected to internet

or network to operate. Once configured the operator can manually start measurements. The analyzer can accumulate data for a few hundred hours of measurement. The analyzer keeps the data even if you turn the analyzer OFF. The data can be transferred when connected either to a computer or network.

3.5.8 LiMCA III supplies

To operate, the system requires AC voltage, compressed air for cooling purposes, and pressurized argon to force the metal in and out of the probe.

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3.6 About inclusion concentration indicators

The purpose of the LiMCA III system is to produce inclusion concentration data. The system expresses inclusion concentrations in amount of inclusion per unit of sampled liquid metal. Some indicators are calculated from the data of one sample. They are said to be sample-related. Others are calculated on data from the whole sample lot. They are said to be sample-lot-related. Table 3 lists and defines the various inclusion indicators calculated by the LiMCA system.

Table 3: Inclusion concentration indicators definition

Indicator	Applies to	Representation & units	Description
N20	Sample	Numerical [K/kg]	Number of inclusions with a diameter greater or equal to 20 μm in thousands of particles per kilogram of liquid metal.
Nxx	Sample	Numerical [K/kg]	Number of inclusions with a diameter greater or equal to xx μm value in thousands of particles per kilogram of liquid metal.
C20	Sample	Volumetric [PPB]	Volumetric concentration of inclusions of diameter greater or equal to 20 μm in Parts Per Billion.
Cxx	Sample	Volumetric [PPB]	Volumetric concentration of inclusions of diameter greater or equal to xx μm value in Parts Per Billion.
N20avg	Sample lot	Numerical [K/kg]	Average number of inclusions with a diameter greater or equal to 20 μm in thousands of particles per kilogram of liquid metal.
C20avg	Sample lot	Volumetric [PPB]	Average volumetric concentration of inclusions of diameter greater or equal to 20 μm in Parts Per Billion.
C20sc	Sample lot	Volumetric [PPB]	Statistically Corrected volumetric concentration of inclusions of diameter greater or equal to xx μm value in Parts Per Billion.

Shows the quality of the metal based on the volumetric concentration of inclusions with a particular emphasis on the transient occurrence of large size inclusions (suspected to be the cause for the rejects of final products).

Notes about inclusion concentration indicators:

- * N20 is the most widely used LiMCA inclusion concentration indicator in publications. It was the first indicator used in the early years of the LiMCA technology. The limit of 20 μm comes from the lower measurement limit of the LiMCA I and LiMCA III systems.
- * Volumetric indicators are useful to highlight the presence of large inclusions in very clean metal.

3.7 LiMCA III inclusion data formats

The LiMCA III system produces inclusion data in CSV format that is easily opened in any spreadsheet for analysis or statistical calculations.

3.8 LiMCA III operation overview

Operators control and monitor the analyzer either directly locally with the manual controls or with a computer having internet browser while being connected to the LiMCA III analyzer. The web browser interface also provides tools to acquire, review and archive LiMCA data.

You can also automate the control, monitoring and data transfer of the analyzer from a remote computer system through Ethernet interface.

LiMCA III data in CSV format are automatically archived on the LiMCA III internal processor and can easily be transferred to a computer through an Ethernet connection.

3.9 LiMCA III web browser interface overview

The LiMCA III internet interface is the primary graphical user interface (GUI) tool to control, monitor and configure the LiMCA III analyzer. The application also provides complete set of tools to view and manage the inclusion, status and log data produced by the LiMCA III system. The main screen of the LiMCA III application is shown in “Figure 18: LiMCA III main screen” on page 23.

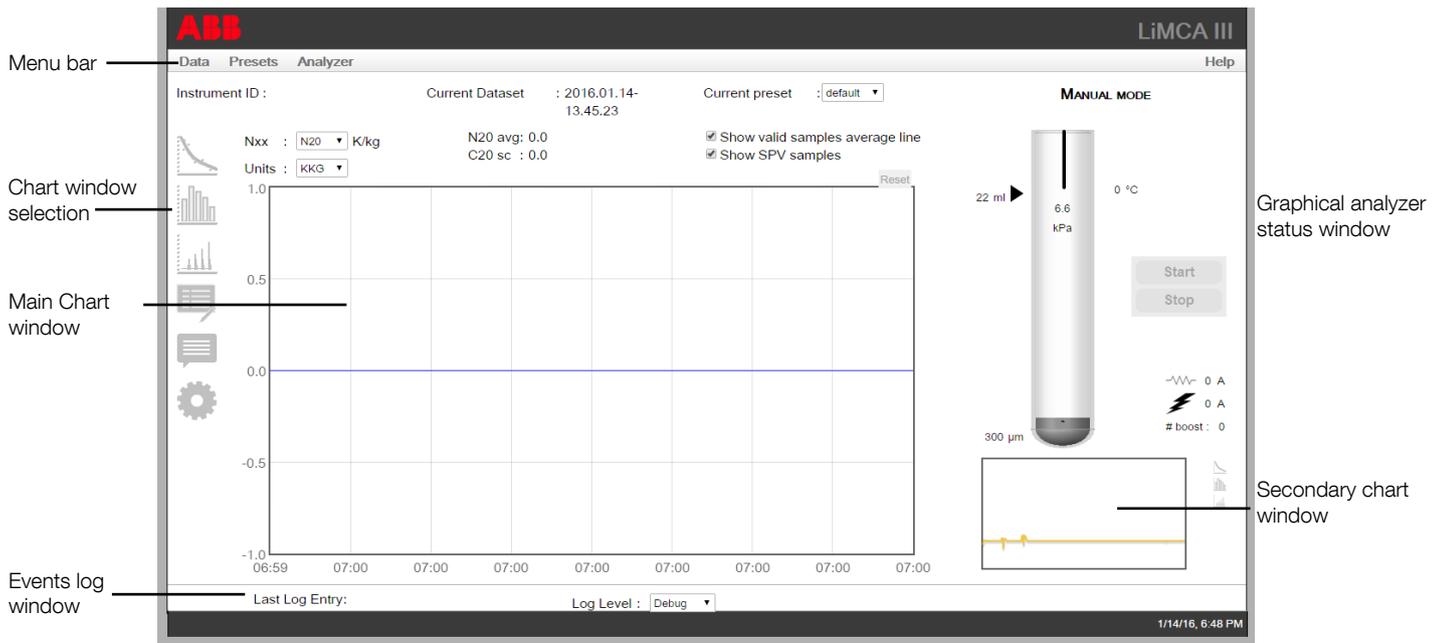


Figure 18: LiMCA III main screen

The main screen of the LiMCA III application is made of the following components:

Menu bar

Provides access to other software functions.

Graphical analyzer status window

Displays graphical and numerical status representation for easy monitoring of analyzer operation. Provides START/STOP control buttons.

Main chart window

Displays inclusion data in Time Display, Histogram or Oscilloscope representations. Also provides chart Configuration and time display of other data properties.

Chart window selection

Icons to select alternative function of the chart window: Timeline, Histogram, Oscilloscope, Configuration (Edit data related to your dataset: site, center, furnace, alloys, etc), Comments (associated with the dataset) and configuration of default graph view settings.

Secondary chart window

Presents the timeline, histogram or online oscilloscope view of Electric Sensing Zone (ESZ) signal. These views can be selected by clicking on the corresponding icons.

Events log window

Shows last events linked to the analyzer operation in tabular form.

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3.10 About melt consumables

The LiMCA III system components getting in contact with the liquid metal are consumable parts:

Number	Part number	Description
1	LMA0500D	The main consumable part is the probe as it needs to be replaced after each immersion.
2	0050-19-0-00003-01	LiMCA III in-probe electrode (lot of 4); to be replaced when they show significant signs of deterioration
3	0050-19-0-00002-01	LiMCA III external electrodes (lot of 4); to be replaced when they show significant signs of deterioration
4	0050-19-0-00004-01	In-probe melt detector thermocoupe (lot of 5) and thermocouple seal H/W spares (lot of 2)
5	0050-19-0-00005-01	In-probe safety level assembly (lot of 2)
6	0004-19-0-00003-01	Maximum immersion detector (lot of 2)
7	AA011856-01	Heat deflector

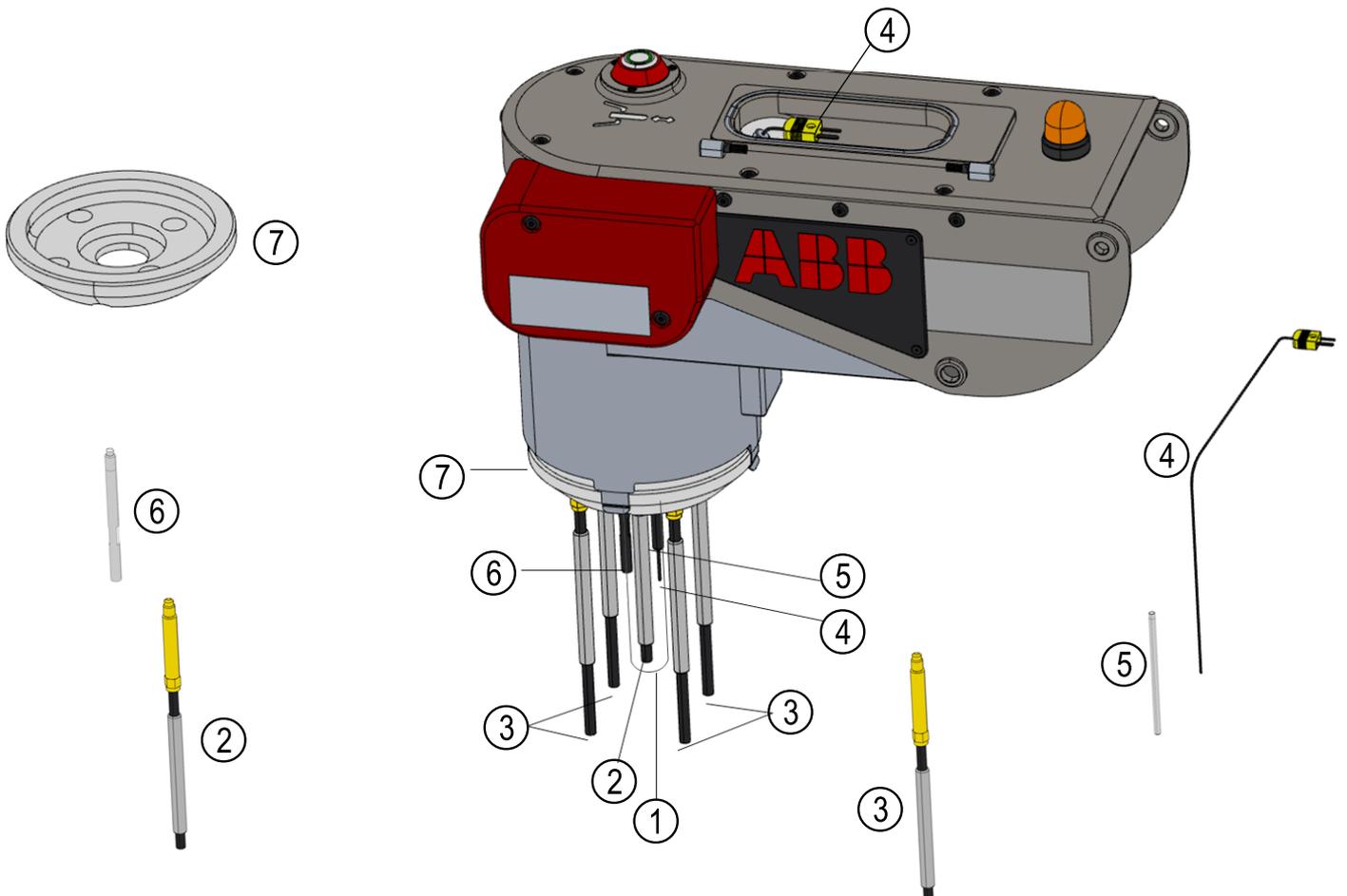


Figure 19: Consumable parts in contact with the melt

3.11 Locating & identifying analyzer internal modules

The LiMCA III analyzer internal hardware components are built-in modules. The figure below provides the identification and the location of the hardware modules in the analyzer. “Figure 20: Analyzer main enclosure internal modules” on page 25 shows an open analyzer main enclosure with the front enclosure door removed, allowing seeing most modules.

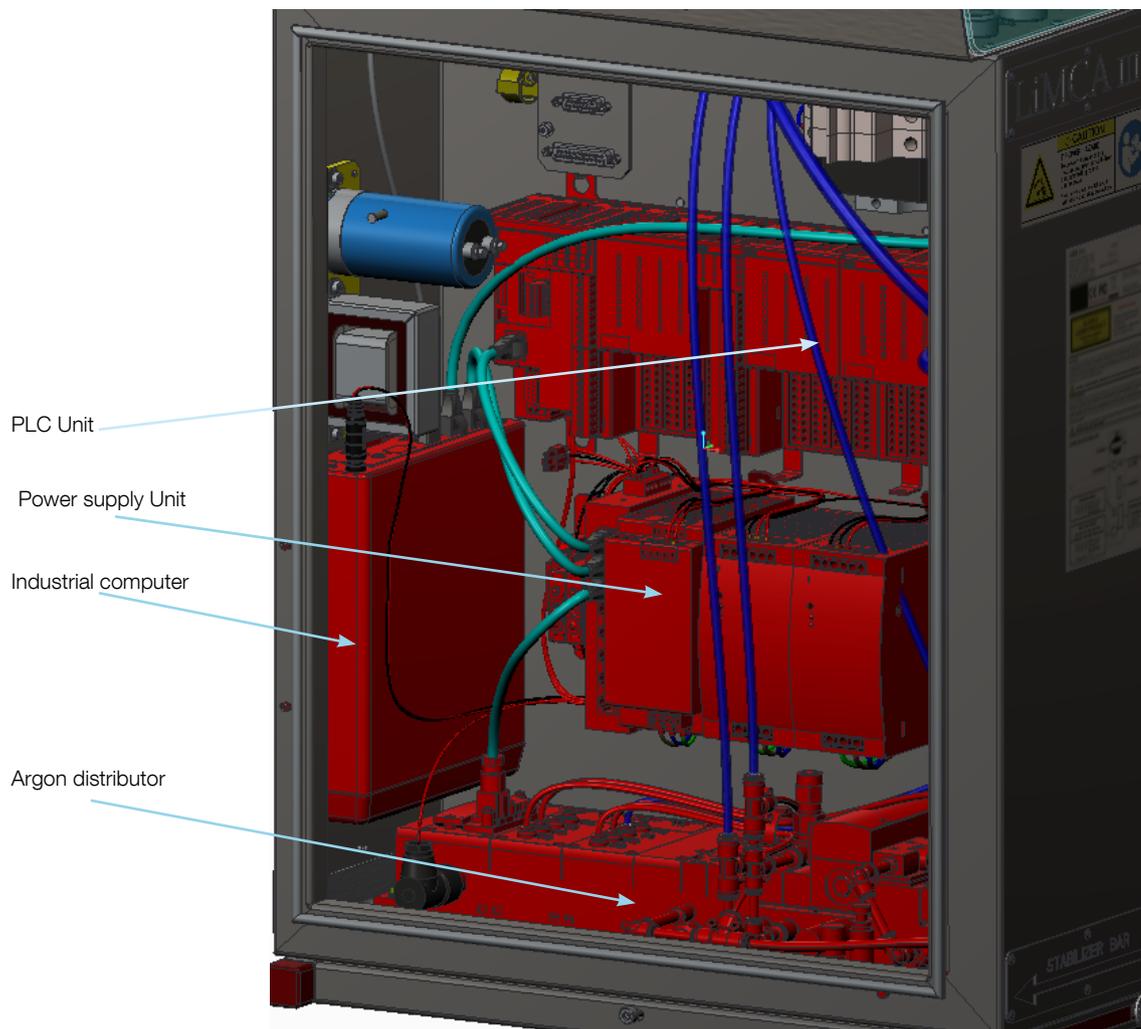


Figure 20: Analyzer main enclosure internal modules

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3.12 More information on the LiMCA III system

All the LiMCA III system documentation is available directly from the Help menu of both the server and the software (see “Figure 21: Help menu” on page 26 below).



Figure 21: Help menu

The first Help menu item is referring to the LiMCA III System User Manual in PDF format. This manual incorporates all user information. In the PDF file, search information using the table of contents, the internal document hyperlinks or the Acrobat Find function.

The About... menu item provides various information such as:

- Family of product
- Application name and release version number
- Software copyright notice
- E-mail address to reach ABB for support and ABB web site address

3.13 Analyzer transportation case

The analyzer transportation case illustrated in “Figure 23: Analyzer transportation case” on page 26 allows for safe shipping, transportation and storage of the LiMCA analyzer.

The case conveniently accommodates the analyzer with its consumables and spare parts. The case exterior is covered with embossed aluminum sheeting. The interior is covered with hard foam. Two of the wheels are swivel and all four have locks. The LiMCA III transportation box has a ramp to allow the LiMCA III instrument to be pushed inside the box by one person when the box

is placed on one side. Refer to “Figure 22: Analyzer transportation case on one side” on page 26.

Table 4: Analyzer transportation case specifications

Analyzer case part number	AA001535-01
Analyzer case width	141.1 cm (55.5 in)
Analyzer case height	76.5 cm (30.1 in)
Analyzer case depth	68.6 cm (27 in)
Analyzer case mass	65 kg

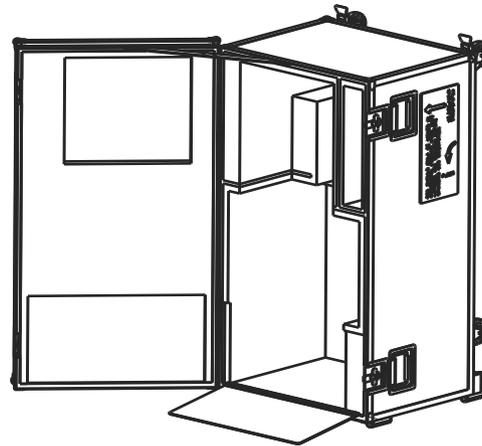


Figure 22: Analyzer transportation case on one side

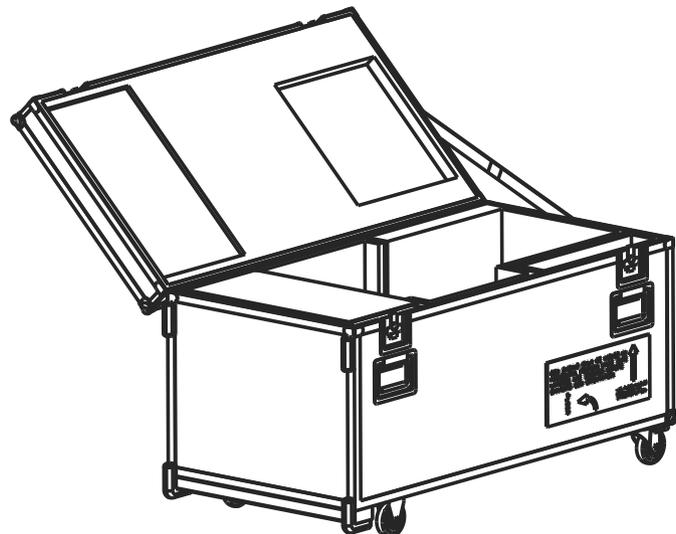


Figure 23: Analyzer transportation case

3.14 Cooling system

The cooling system has been designed to cool down the head electronic components and the main body cabinet .

The LiMCA III system is generally installed in an environment with numerous close by heat sources. The proximity and contact with liquid metal during measurement being the first of these heat sources. Surrounding metal processing equipment (furnaces, trough, degasser, filters, etc.) together with hot cast metal pieces all contribute to warming up the LiMCA III system. The ambient temperature in the plant following seasons can also vary significantly from rather cold to high values. Because of all these variable parameters, the LiMCA III includes an automated cooling system.

The LiMCA III system is cooled using compressed air in conjunction with two vortex-cooling devices. The instrument continuously monitors several temperatures of individual zones and controls (ON/OFF) compressed air supply to the vortex cooling devices to maintain the analyzer internal temperatures to appropriate values.



WARNING – Property damage

Failure to supply dry compressed air to the LiMCA III system may result in water dripping from the analyzer. Water dripping on process components to be in contact with liquid metal can cause an explosion.



WARNING – Property damage

Make sure to continuously supply the LiMCA III system with compressed air to prevent overheating damages to the system.

The LiMCA III cooling system consists of:

- Vortex cooler device in the main body
- Vortex cooler device in the head.
- Constant airflow leak to the Laser compartment to keep the laser window cool and clean.
- Heat shield to protect the LiMCA III head.



WARNING – Property damage

Excessive system cooling in a humid environment can cause condensation on system components. Make sure to prevent water dripping on materials that may be in contact with liquid aluminum to eliminate explosion risks.



Attention - Important information

For particular contexts, an ABB service engineer can revise threshold zone temperatures used by the instrument to turn cooling ON/OFF to optimize the cooling operation.

3.14.1 Cooling system technical details

The following lists technical details relative to the cooling system:

- The main body and head vortex cooling devices share the same compressed air line.
- The system turns cooling ON only when it needs to be cooled, thus saving compressed air and minimizing risks of condensation on system components.
- The compressed air valves for both the main body and the head are normally open. This means that when the system power is turned OFF but connected to compressed air, compressed air flows in both vortex devices. This protects the hardware from being damaged if left with no power in a hot environment.
- The flow of cooled air is distributed by tubing to the modules that pick up heat from the environment (head, laser) or generate heat. Most of the cooled air is blown in the mandrel or head and escapes slowly through. The air that cools down the head escapes just above the heat shield.
- The analyzer main body enclosure is under positive pressure (when connected air) to prevent internal components to be exposed to dust and corrosive substances that may be present in the environment and to force cooled air to escape by the port located on the top of the analyzer,

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Attention - Important information

The Compressed air input pressure value reported by the software in the status window drops significant whenever the cooling is ON for either vortex devices. The pressure drop is due to flow restriction in the piping, both inside and outside the LiMCA III system. The pressure drop percentage depends on the pressure and flow that your compressed air system can supply but can be up to 45%!

- The system will generate an error message that the input compressed air pressure is too low when it goes below 265kPa (38PSI).

3.15 System connection

System connections are made at the connection panel (see "Figure 24: Analyzer connection panel" on page 28 below) on the left-hand side of the main body.

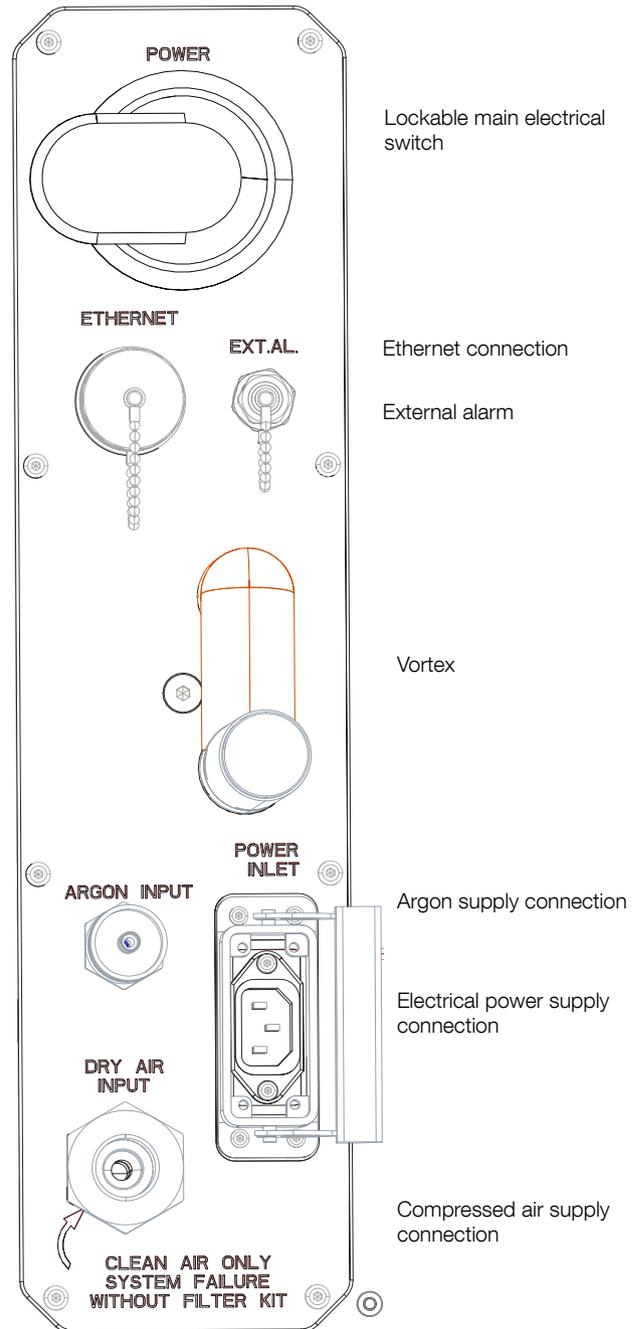


Figure 24: Analyzer connection panel

Make the following system connections at the connection panel, starting from the top of the panel:

1. Connect the Ethernet network cable to the RJ-45 socket. Lock the sealing connector cover to protect the connection from the environment.



Important

It is also possible to operate the LiMCA III completely manually with the manual command buttons on both sides of the instrument.

2. EXT ALConnect the external alarm cable (if applicable).
3. Connect the compressed argon supply hose in the associated socket.
4. Connect the power cable to the associated socket and lock its protective hood.
5. Connect the compressed air supply hose in the associated socket

3.15.1 Ethernet connection

It is possible to connect a laptop directly into the Ethernet port.

6. Connect the Ethernet network cable to the RJ-45 socket. Lock the sealing connector cover to protect the connection from the environment.

3.15.2 External Alarm

The external alarm can be connected to an alarm light that can be seen throughout the casthouse. The pinout for this cable is illustrated below. Ext. Alarm signal voltage is 24 V.

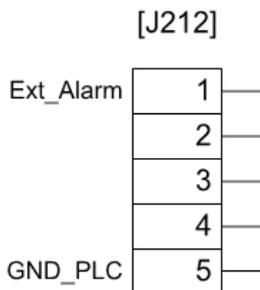


Figure 25: Pinout for the external alarm cable

3.15.3 Testing the external alarm

To test the external general alarm signal:

1. On the LiMCA III neck push the Emergency stop button. This generates an alarm condition. The alarm indicator on the LiMCA III head flashes.
2. If connected to a local alarm light, verify that the alarm light is ON.
3. Pull the Emergency stop button. This terminates the alarm condition. The alarm indicator stops flashing.

3.15.4 External Emergency out signal

The analyzer activates this signal if it is overheating or if it is in a fatal alarm state. It is not recommended to voluntarily bring the analyzer to an overheating condition and not desirable to create a voluntary fatal state. Therefore, ABB service personnel only can test this signal.

3.16 Positioning system

The purpose of the positioning system is to measure and control the relative position of the LiMCA III head with respect to the liquid metal surface.

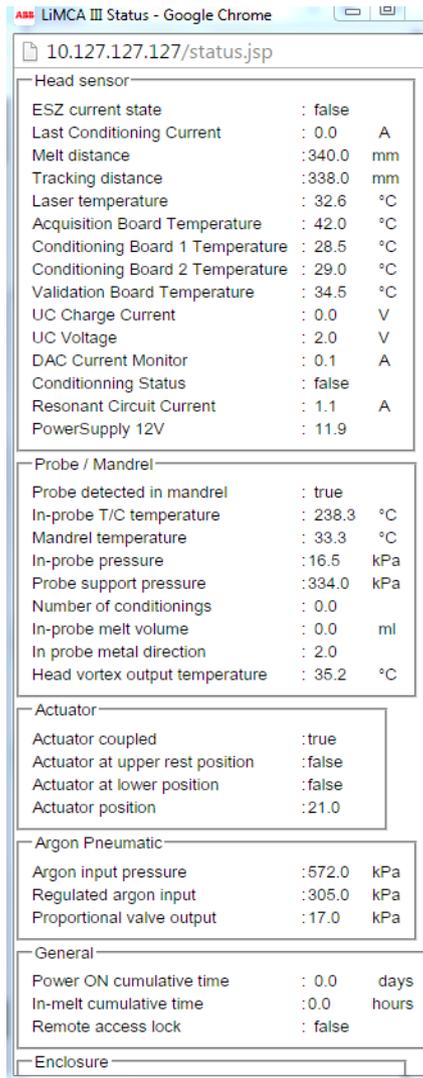
The measurement of the position is performed by the laser and the measurement is indicated in mm. The positioning software controls the internal motor to adjust the height of the head the the neck.

The positioning system reports the relative position of the LiMCA III head with respect to the liquid metal surface as the “Melt distance” in milimeters. Consequently, this distance decreases as the LiMCA III probe immersion increases.

The “Melt distance” value is continuously displayed in the Detailed status window. Click on Analyzer menu and Detailed Status (see “Figure 46: LiMCA III-Analyzer Detailed status window” on page 53).

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The screenshot shows the LiMCA III Status page in Google Chrome. The browser address bar displays "10.127.127.127/status.jsp". The page content is organized into several sections, each with a title and a list of parameters and their values:

Head sensor		
ESZ current state	: false	
Last Conditioning Current	: 0.0	A
Melt distance	: 340.0	mm
Tracking distance	: 338.0	mm
Laser temperature	: 32.6	°C
Acquisition Board Temperature	: 42.0	°C
Conditioning Board 1 Temperature	: 28.5	°C
Conditioning Board 2 Temperature	: 29.0	°C
Validation Board Temperature	: 34.5	°C
UC Charge Current	: 0.0	V
UC Voltage	: 2.0	V
DAC Current Monitor	: 0.1	A
Conditioning Status	: false	
Resonant Circuit Current	: 1.1	A
PowerSupply 12V	: 11.9	

Probe / Mandrel		
Probe detected in mandrel	: true	
In-probe T/C temperature	: 238.3	°C
Mandrel temperature	: 33.3	°C
In-probe pressure	: 16.5	kPa
Probe support pressure	: 334.0	kPa
Number of conditionings	: 0.0	
In-probe melt volume	: 0.0	ml
In probe metal direction	: 2.0	
Head vortex output temperature	: 35.2	°C

Actuator		
Actuator coupled	: true	
Actuator at upper rest position	: false	
Actuator at lower position	: false	
Actuator position	: 21.0	

Argon Pneumatic		
Argon input pressure	: 572.0	kPa
Regulated argon input	: 305.0	kPa
Proportional valve output	: 17.0	kPa

General		
Power ON cumulative time	: 0.0	days
In-melt cumulative time	: 0.0	hours
Remote access lock	: false	

Enclosure		
-----------	--	--

Figure 26: Melt distance

The function of the “Maximum Immersion Detection probe” is to protect the LiMCA III head hardware. When the liquid metal surface gets in contact with the tip of this probe, the system performs an emergency withdrawal of the LiMCA III probe from the metal. The following high priority error message is also emitted at the LiMCA III computer:

“Maximum immersion level reached -- Raising analyzer”.

4 Site and system preparation and installation

This chapter contains information on how to correctly install your LiMCA III system, and how to prepare it for use. It also includes information on gas supply and electrical requirements.

4.1 Personal protection equipment necessary for installation

Make sure to comply with the plants security regulations. Personal protection equipment is mandatory. Below is shown the minimum equipment to be used.

Safety shoes	
Gloves	
Protective glasses	

4.2 Layout in the cast house

The layout of the LiMCA III system should not impede normal operations in the casting center. The LiMCA III system was designed with this fact in mind. The instrument's ergonomic design requires but little space along the transfer trough, and its convenient dolly allows rapid removal from the testing site.

However, the LiMCA III system requires a supply of gas and electricity. This makes the use of hoses and cables necessary. It is therefore recommended that argon and power outlets be custom installed in every DC center where the instrument is to be used frequently. In other DC centers, where only occasional measurements need be taken, a basic set of flexible hoses and cables would be sufficient.

The following considerations should be taken into account when selecting a LiMCA III measuring location.

- The LiMCA III dolly can be positioned by the side of the

trough. There is enough room to lower the probe into the melt and remove it after data have been collected.

- The space available by the trough is wide enough for both the instrument and an operator. It is very useful to be able to work around the instrument and to have access to the liquid metal in the launder.
- All safety regulations are respected. In any setup, the safety of the operators and the machine must be taken into account.

4.3 Using the lifting kit

The LiMCA III system is delivered with the lifting kit in place to allow for easy positioning. This lifting kit is to be used when moving the LiMCA III system with a lift. For operation, the lifting kit should be disengaged. Simply remove the quick release pins and install the horizontal lifting kit bar on one side.

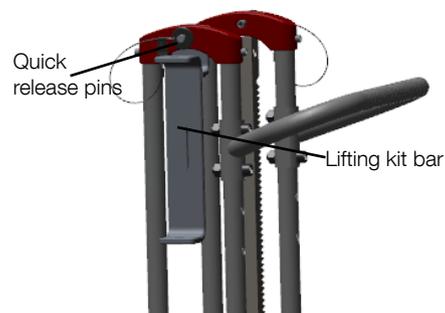


Figure 27: Disengaged lifting kit bar

4.4 Gas supply and electrical requirements

The LiMCA III system needs electricity, compressed air, and a supply of argon in order to operate.

4.4.1 Electrical supply

The electrical design of the LiMCA III system has been made to adapt to different international standards. The LiMCA III system will adjust itself to the electrical supply of your country.



WARNING – Property damage

If you travel with your LiMCA III instrument, before operating the instrument, ensure that the electrical power connector of the LiMCA III is in conformity with the local power supply.

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4.4.2 Gas supply

Air pressure is necessary to maintain adequate temperature inside the instrument. The air supply must be free of oil and water. The instrument is supplied with an air filter mounted on the dolly but another stage of filtration before this one is highly recommended.



WARNING – Bodily injury

Compressed air cooling may generate a sound pressure level above 85 dBA. If it is necessary for the operator to stay closer than one meter from the instrument, he must wear appropriate ear protection.

Argon is used in the pneumatics of the measurement system because it is inert and does not react with aluminum. Argon is the gas in contact with the aluminum in the probe and is the medium for vacuum and pressure in order to move metal into and out of the tube. No special argon grade is necessary. Ordinary, welding-quality argon is adequate.

Pressure adjustments are made inside the instrument and do not require any intervention on the part of the user. However, adequate air and argon pressures have to be supplied to the LiMCA III system, to avoid malfunction.

Air pressure requirements	Min.: 80 psi (552 kPa)
	Max.: 200 psi (1400 kPa)
Argon requirements	Average consumption: 17 (max 25 scfm) (481 SLPM)
	Min.: 45 psig (300 kPa)
	Max.: 115 psig (800 kPa)
Electrical specifications	Average consumption: 0.5 scfm (0.015 m ³ /min)
	100-240 VAC autoselect
	47 Hz to 63 Hz automatically adjusted
	Average consumption: 200 VA
	Peak: 450 VA

4.5 Ethernet connection

To connect the instrument with the laptop computer LiMCA III, use a standard RJ-45 Ethernet cable. One 5 m (16 ft) cable is supplied with the LiMCA III system. One end of

the cable connects to the Ethernet serial port of the laptop, the other connects to the LiMCA III interface panel, refer to “Figure 24: Analyzer connection panel” on page 28.

4.6 Installing the heat shield

The heat shield is a ceramic heat shield part covering the bottom part of the LiMCA III head to cut heat radiation and convection.



WARNING – Property damage

Operating the analyzer above the melt without the heat shield installed may result in analyzer overheating conditions that will cause the system to withdraw the analyzer from the melt.

To install the heat shield on the analyzer refer to “4.6 Installing the heat shield” on page 32

4.7 Consumables installation and replacement

Several parts of the instrument are likely to require frequent replacement. These are the glass sampling probe, the electrodes and the probe seal together with the thermocouples, located inside the pneumatic mandrel. The replacement of these parts is described in the following subsections. Please refer to “Figure 19: Consumable parts in contact with the melt” on page 24 to identify the parts.



WARNING – Property damage

To protect the sensing head probes from being damaged and to protect your personnel from being burned, make that the maximum immersion detector is always in place even when the system is not used, stored or being moved.

4.7.1 Probe

The probe is the main consumable It must be changed after it is taken out of the metal.

To change the probe, the head must be out of the metal. It is also preferable to have the probe empty of metal.

The probe support of the LiMCA III analyzer is equipped with a probe insertion detector. The detector consists of a spring-loaded pin located in the mandrel that activates two switches when pushed by an inserted probe. The Analyzer automatically grabs the probe when the operator inserts the probe in the mandrel. If the light is OFF, no probe is detected

in the probe support. If the light is ON, a probe has been detected and is grabbed by the support. If the light flashes, then the probe is being ejected.

To install a probe:

1. Carefully slide the probe around the in-probe components (in-probe electrode and In-probe melt level detector) and fully insert it up in the mandrel.
2. Verify that the instrument has grabbed the probe, confirming that the Probe button indicator on the LiMCA III head is ON.

4.7.2 Electrodes

Electrodes should be replaced when they show signs of degradation or when tightening them does not eliminate abnormal ESZ signal noise, noted repetitively with a few consecutive probes. There is no distinction in the electrode type. But it is important to remember that the LiMCA III can only produce a result if the current is established between the in-probe electrode and the external electrodes.

The electrodes are simply screwed at their respective locations in the mandrel module at the bottom of the analyzer head. You can install or replace the electrodes even when the heat shield is installed on the analyzer.

The analyzer needs four electrode that are installed outside the probe one electrode inside the probe.



WARNING – Property damage

The only visible difference between the in-probe and external electrodes is their length.

The in-probe electrode has a length of 195 mm and the external electrodes have a length of 220 mm. Make sure to install the proper external electrodes. If the in-probe electrodes are installed by mistake at the external electrode locations, the LiMCA III head is immersed into the metal too far and the probe is likely to be damaged.



Attention - Important information

Initially screw the electrodes using fingers and tighten it using the small adjustable wrench. Electrodes must be screwed tightly to ensure a very good electrical contact and not easily get loose with thermal cycles.



WARNING – Property damage

Be careful to not break an electrode by over-tightening it.

How to install or replace the electrodes:

1. Remove each old electrode by unscrewing it (turn counterclockwise when looking up at the electrode) using the small adjustable wrench.
2. First install the in-probe electrode, (see “[Figure 19: Consumable parts in contact with the melt](#)” on page 24). It is slightly shorter than the external electrodes. Screw it (turn clockwise when looking up at the electrode) into its socket inside the probe.
3. Install the external electrodes, (see “[Figure 19: Consumable parts in contact with the melt](#)” on page 24) Screw them in their sockets at any location outside of the probe.

4.7.3 Maximum immersion detector

The maximum immersion detector (004-19-0-00003-01) (see “[Figure 19: Consumable parts in contact with the melt](#)” on page 24) is a 6 mm (1/4 inch) diameter steel rod installed at the bottom of the analyzer head. Its tip is located at the closest distance the analyzer can get to the melt surface without being fatally damaged. In normal operation, the analyzer shall never get this close to the melt. The maximum immersion detector is there to detect such cases. The analyzer will automatically withdraw from the melt whenever the maximum immersion detector tip touches the melt.

You can install or replace the maximum immersion detector even when the heat shield is installed on the analyzer.

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WARNING – Property damage

Failing to install or properly tight the maximum immersion detector may result in significant damages to the analyzer as it can be immersed in the melt if the vertical positioning measurement or control problem occurs.

How to install or replace the maximum immersion detector:

1. Remove the old maximum immersion detector (turn counterclockwise when looking up at the electrode) using the small adjustable wrench.
2. Install the new maximum immersion detector in its socket on the right side of the mandrel by initially screwing it by hand.
3. Using the small adjustable wrench tightly screw the detector in its socket. The detector must be screwed tightly to ensure a very good electrical contact and not easily get loose with thermal cycles.



WARNING – Property damage

Be careful to not break the maximum immersion detector by over-tightening it.

4.7.4 Installing or replacing the in-probe melt level detector

The in-probe melt level detection thermocouple (0050-19-0-000004-01) (see “[Figure 12: The LiMCA III neck](#)” on page 17) is installed in the probe through in-probe melt level detector service trap on top of the analyzer head. The system detects that the probe is filled when the melt touches the tip of the in-probe melt level detector thermocouple.

The system also detects that the probe is excessively full when the melt touches the thermocouple safety tubing. The system then immediately sets the in-probe pressure to atmosphere to prevent the melt from reaching the mandrel.

How to install the in-probe melt level detector:

1. Open the service trap on top of the LiMCA III head.



WARNING – Property damage

Failing to perform and complete the zero energy procedure before working with inner analyzer component may expose the operator to electrical and pneumatic hazards.

2. Disconnect the yellow connector, refer to [Figure 28](#).

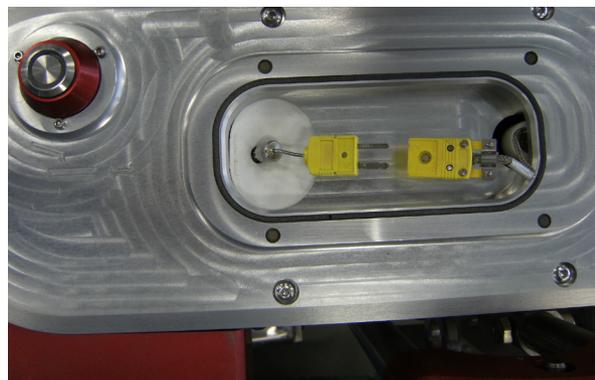


Figure 28: In-probe melt level detector connector

3. Remove the old in-probe melt level detector.
4. If an in-probe melt level detector is present in the mandrel:
 - Unscrew the thermocouple safety tubing (AA006308-01) and remove the thermocouple safety tubing and the insulation tubing (AA006309-01) from the in-probe melt level detector (0004-08-0-00007-01).
 - Disconnect the thermocouple at the top of the in-

- probe melt level detector.
- Loosen the in-probe melt level detection sealing nut with your fingers and then unscrew completely.
 - Carefully slide up the in-probe melt level detector vertically out of the mandrel without damaging surrounding components.
5. Carefully slide down the new in-probe melt level detector vertically in the mandrel without damaging surrounding components.
 6. Bring the in-probe melt level detector as low as possible.
 7. Fully screw finger tight the in-probe melt level detector sealing nut at the top of the mandrel.
 8. Connect the yellow thermocouple connector at the top of the in-probe melt level detector inside the service trap.



WARNING – Property damage

Failing to properly connect the in-probe melt level detector may result in significant damages to the analyzer as melt could reach the mandrel, if for example, the probe breaks while it is under vacuum.

5 System software installation and configuration

5.1 Software installation

No software has to be installed on a computer as the interface is a web browser. Simply open a web browser and type `http://10.127.127.127`.

The computer used to connect to the LiMCA III instrument has to be configured with a fixed IP address in the same range as the LiMCA III, refer to “5.4.1 Assigning the analyzer IP address” on page 36

5.2 Software configuration summary

At this point, it is assumed that the hardware installation is completed (see Section 4 on page 31). This section offers a summary of the software installation and configuration tasks. The list refers to other sections for more information on specific subjects.

Table 5: Software configuration summary

Tasks

1. Configure analyzer identification parameters (see section “5.3 Configuring the analyzer” on page 35)
2. Assign an IP address to the analyzer, if applicable (“5.4 Network configuration” on page 36).
- 3 Define time setting, refer to
4. Define validation criteria
5. Define preset configuration
6. If an analyzer software update is available, update the analyzer firmware (see section 9.4 on page 68).
7. Create dataset
8. Probe configuration

Numbers 7 and 8 are part of the standard operation and are described in “6.3 Create dataset” on page 46 and “6.4.1 Setting the orifice size from the web browser interface” on page 46.

5.3 Configuring the analyzer

You can configure parameters to describe the context of the LiMCA III analyzer by assigning a name to the analyzer and specifying its location.

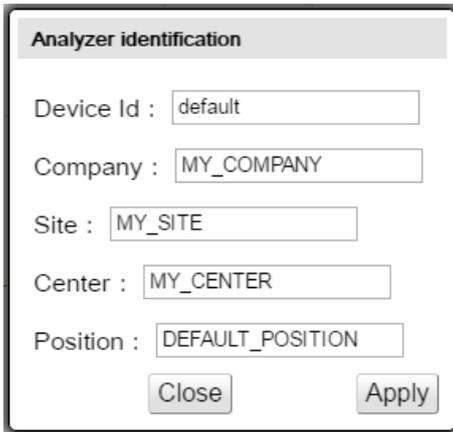
This contextual information is installed is stored in every dataset, thus indicating the origin of the data. It is therefore important to carefully configure these parameters when you first install the system, and whenever you move the analyzer.

To configure the analyzer contextual information:

1. Start or access the web browser interface application.
2. Click on the Analyzer menu and chose Analyzer Identification. (See “Figure 29: Analyzer identification” on page 36 below).

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The dialog box titled "Analyzer identification" contains five text input fields and two buttons. The fields are labeled "Device Id", "Company", "Site", "Center", and "Position". The values entered in the fields are "default", "MY_COMPANY", "MY_SITE", "MY_CENTER", and "DEFAULT_POSITION" respectively. The "Close" button is on the left and the "Apply" button is on the right.

Figure 29: Analyzer identification

3. Type an analyzer label that is meaningful to your operation.
4. Type the company name, the site, the casting center and the process position where the analyzer is installed.
5. When your configuration changes are completed, press the Apply button to bring changes into effect.

5.4 Network configuration

5.4.1 Assigning the analyzer IP address

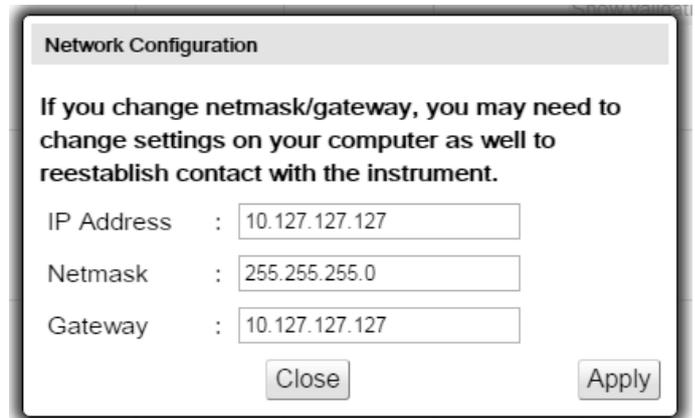
The LiMCA III analyzer needs to have an IP address assigned to connect to a Local Area Network or to another computer. The LiMCA III analyzer supports the configuration for a fixed IP address.

Consult your network administrator to find out the appropriate IP address assignment method for your location.

At the factory, ABB configures the LiMCA III analyzer with fixed IP address (see "Figure 30: Analyzer network configuration dialog box" on page 36).

To configure the analyzer IP address assignment:

1. Start the web browser interface application and connect to the analyzer you want to configure. To connect to the analyzer, make sure to use the IP address and netmasks in the range of the LiMCA's III fixed IP address, for example 10.127.127.126 and netmask 255.
2. Select the Network Configuration item from the Analyzer menu.



The dialog box titled "Network Configuration" contains a warning message and three text input fields. The warning message reads: "If you change netmask/gateway, you may need to change settings on your computer as well to reestablish contact with the instrument." The fields are labeled "IP Address", "Netmask", and "Gateway". The values entered are "10.127.127.127", "255.255.255.0", and "10.127.127.127" respectively. The "Close" button is on the left and the "Apply" button is on the right.

Figure 30: Analyzer network configuration dialog box

3. Revise and modify as needed the network parameters in the Analyzer network configuration dialog box (see "Figure 30: Analyzer network configuration dialog box" above).
4. Click Apply.

5.4.2 How to retrieve an IP address

When the IP address was assigned through a network and was not note it is possible to retrieve the address with this simple procedure.

1. Make sure the instrument is ON and Ready (Ready button is solid white).
2. Insert a USB key. It can be an empty brand new USB key or even one with data but for security reasons we recommend a new USB key.
3. Wait for 10 seconds.
4. Remove USB key
5. Insert the USB key in a computer and access the USB drive that now contains a .txt file with the IP address.

5.5 System time and date synchronization

As the The LiMCA III instrument does not have to be connected to a network connected software system, it has to be manually set or when connected to a network, the time can be retrieved from the network.

It is your responsibility to configure the server computers to periodically get its time and date synchronized with that of the appropriate reference time system.

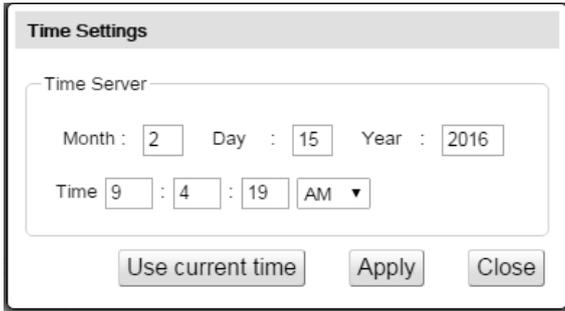


Figure 31: Time Settings dialog box



Attention - Important information

The LiMCA III system will correctly readjust its time following Day Light Saving time corrections. However, it is not recommended to acquire data over the Day Light Saving 1 hour shift correction.

5.6 Configuring validation criteria

The process of sampling metal and analyzing the signal performed by the LiMCA III analyzer can be disturbed when the orifice is partially or completely obstructed. This may affect the validity of the particle size distribution of the sample. For example, the system may overestimate the volume of sampled metal and consequently underestimate the inclusion population of the sample.

When closely watching the signal and continuously monitoring several LiMCA III parameters, an experienced LiMCA operator can detect such cases and manually disable the erroneous samples. However, because these cases are generally rare, systematically and continuously performing this task is tedious. The validation criteria functions are more efficient than an operator in performing this menial monitoring job.

The LiMCA III validation criteria are software functions analyzing inclusion concentration and ESZ parameters data to detect problems in the measurement process. Validation criteria results are associated with each sample. When a criterion detects an invalid condition, the associated sample is disabled. The validation status of samples is visible in the Time Display screen as shown in “Figure 32: Valid and non-valid samples in a Time Display example” on page 37 where empty square blue symbols represent non-valid samples while filled symbols represent valid samples.

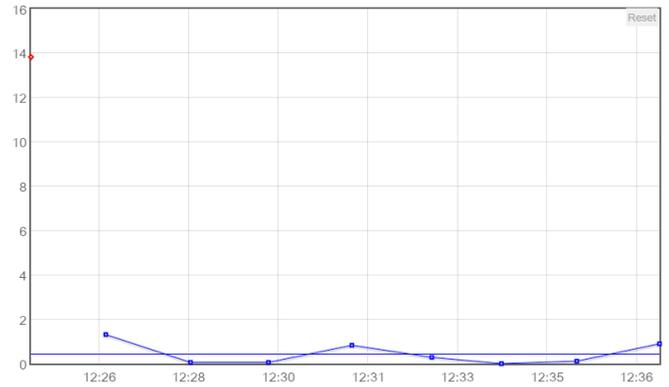


Figure 32: Valid and non-valid samples in a Time Display example

In the Time Display screen, right-clicking the symbol of a sample brings a pop-up window (see example shown in “Figure 33: Sample validation example” on page 37) listing the status of each validation criterion for that sample.

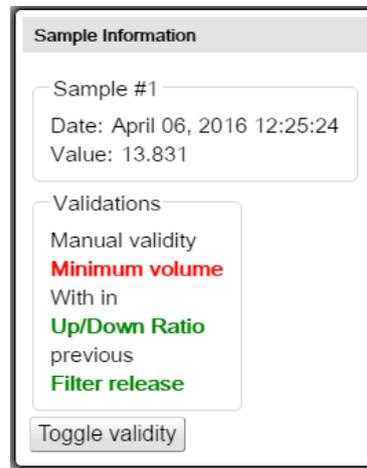


Figure 33: Sample validation example

The LiMCA III validation criteria algorithms are duplicates of that of the LiMCA III software and offer the same configuration parameters (see sections 5.6.1 to 5.6.3).

Technical details about validation criteria:

- Disabled samples:
 - in the Time display chart:
 - Are displayed in red.
 - Sample symbols are not linked by linear interpolation lines.
 - Sample’s validation state can be changed manually (by a user) by right clicking on the

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sample's symbol and selecting Toggle validity in the contextual popup menu.

- A user can review the validation state of a sample by right clicking on the sample's symbol and selecting Show sample validation... in the contextual popup menu.
- Not taken into account for dataset wide indicators (Nxxavg, Cxxavg, and C20sc).
- External Calibration samples are not taken into account.
- All criteria are independent from each other. Samples disabled by other criteria are taken into account.

To configure validation criteria, select Validation criteria... from the Analyzer menu. Figure 34 below shows the available configuration parameters. In the console, position your cursor over a parameter label to get the parameter description.

It is recommended to keep the Enable validation criteria selected to always keep these functions active.

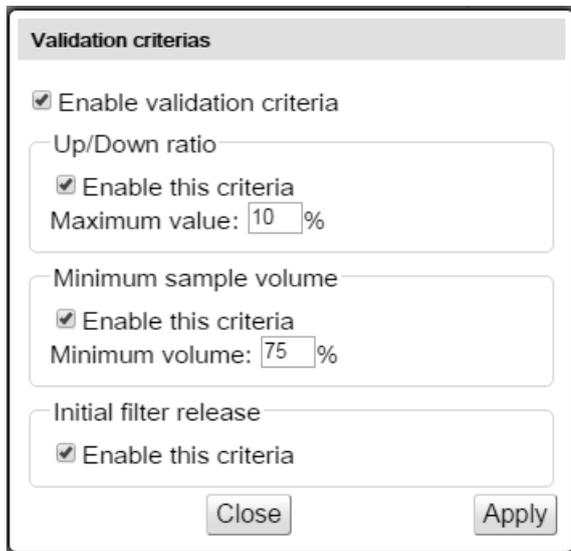


Figure 34: Configuring validation criteria

5.6.1 About the Up/Down ratio validation criterion

The Up/Down ratio criterion is used to disable samples for which there is an uncertainty on the sample volume estimate.

During each measurement cycle, the LIMCA III system evaluates the volume of metal that flows in and out of the probe. Obviously, cycle after cycle, the volume of metal flowing in the tube should be equal or at least close to the

volume of metal flowing out. Therefore, the ratio of the two volumes, the Up/Down ratio, for a given sample, should be close to one.

Unfortunately, the system cannot continuously measure directly the volume or level of metal in the probe. The level is measured only when the metal reaches the "Metal thermocouple". Otherwise, the volume of metal sampled (or ejected) is estimated and integrated every tenth of a second, based on the orifice size and the pressure in the tube.

Parameter	State (Up/Down ratio)
Description	Enable validity evaluation for ratio of estimate fill volume over estimate flushed melt volume (Up/Down ratio).
Default value	Enable
Recommendations	Keep enabled unless it becomes an irritant.

Parameter	Maximum value (Up/Down ratio)
Description	Up/Down ratio threshold value above which the sample will be disabled.
Default value	125%
Recommendations	Reduce the value down to 110% to increase the sensitivity of the criteria.

5.6.2 About Minimum sample volume validation criteria

The Minimum sample volume criterion is used to disable samples for which the sampled volume is below an acceptable minimum value.

The sample volume is typically of the order of 7 ml. If the orifice is obstructed during the emptying of the probe, the volume sampled during the filling can be significantly lower than the typical or target volume.

One should consider this criterion from a statistical error point of view. Obviously, a particle size distribution extracted from a 7 ml sample will have more weight than one extracted from a 1 ml sample. The statistical error associated with the particle size distribution data extracted from the sampled metal is linked to the number of particles detected in the sample. The higher the number of detected particles, the lower the statistical error.

Following this logic, an acceptable Minimum sample volume should be set to a lower value when analyzing rather dirty metal. On the contrary, when the analyzed metal is very clean

and a small number of particles are detected within a sample, the Minimum sample volume should be set to a value closer to the target volume.

Parameter	State (Minimum sample volume)
Description	Enable validity evaluation of the sample based on minimum melt sample volume.
Default value	Enable
Recommendations	Keep enabled unless it becomes an irritant.

Parameter	Minimum value (Minimum sample volume)
Description	Melt volume threshold value below which the sample will be disabled.
Default value	75%
Recommendations	Reduce the value down to 25% to reduce the sensitivity of the criteria.

5.6.3 About the Initial Filter Release validation criterion

When a cast starts, deep bed type filters often initially but decreasingly release previously trapped inclusions. The initial filter release validation criteria analysis the N20 values for initial samples of a dataset, looking for a decreasing trend. If one is found, all initial samples associated with this decreasing N20 value trend are disabled.

Technical details for the initial filter release validation criteria:

- Algorithm duplicated from software.
- Based on N20 values of valid samples only.
- Starts to be active only after acquisition of 30 samples in the dataset. Re-evaluation of initial filter release at reception of each other sample.
- About the Filter release duration parameter:
 - Definition: time difference between the start cast time and the end of the initial filter release (time of last disabled sample).
 - Value calculated only if a valid start cast time value is available and the initial filter release criteria has disabled samples.
 - Value displayed in the Time display above the chart.

5.7 About analyzer configuration presets

An analyzer configuration preset contains one set of values for all the analyzer parameters available under Analyzer configuration. You can select a preset to quickly configure the analyzer in a known state without having to individually review and edit each parameter.

You can select a preset from the Presets Menu (see “Figure 58: Preset choice dialog box” on page 59) by clicking the Import button. In the Preset choice dialog box (see “Figure 58: Preset choice dialog box” on page 59), select the desired preset.



Attention - Important information

The analyzer configuration preset includes the calibration factor of the analyzer. In the case where more than one analyzer is managed from a given computer, do not apply a preset created with a given analyzer to another analyzer as this will overwrite the calibration factor of the target analyzer. To bypass this problem, identify the analyzer in the name of the preset and use the preset exclusively with that analyzer.

5.7.1 Using analyzer configuration presets

You can create as many presets as you want to cover the various typical operating conditions. Try to pick preset names that well identify the conditions for which they were created and that are obvious to all users.

You can select a preset from the Presets menu or define a new preset (see “Figure 36: Analyzer settings (Preset) - Before measurement” on page 40). In the Preset choice dialog box (see Figure 38), select the desired preset.

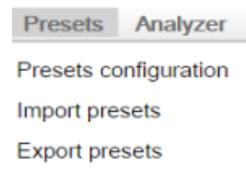


Figure 35: Presets menu

5.7.2 Configuring the „Before measurement“ sequence

In the Preset dialog box the default preset is displayed. In case any value is modified it is recommended that a new preset is created to allow loading the default in case of need. Simply click on the + sign besides the default preset and

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save the preset with a meaningful name. Refer to “Figure 36: Analyzer settings (Preset) - Before measurement” on page 40.

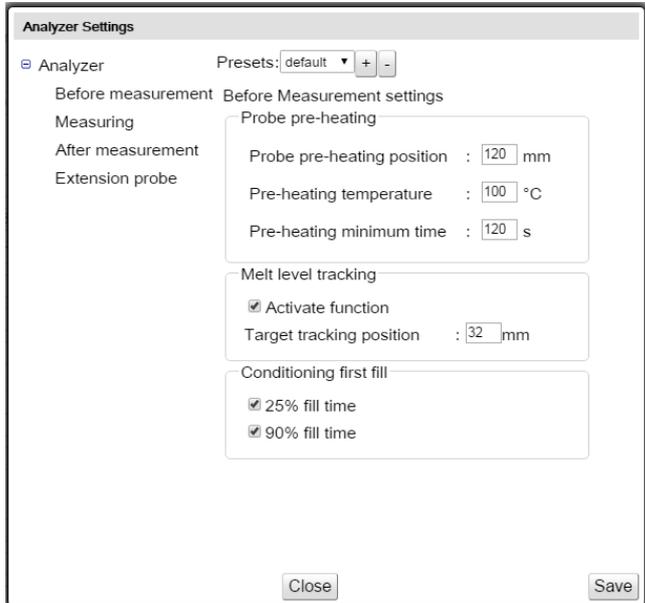


Figure 36: Analyzer settings (Preset) - Before measurement

The default values for the Preparing for measurement parameters will work in most cases. If probes tend to break from thermal shock during or following preheating, consider the advices in sections 5.6.1, 5.7.2.2 and 5.7.2.3.

5.7.2.1 Configuring probe preheating

The Probe pre-heating parameters allow tuning how the probe is preheated before coming in contact with the liquid metal. A Pre-heating position of 120 mm normally prevents the probe from touching the liquid metal surface while pre-heating, thus minimizing risks of breaking it by thermal shock. Increase this value in the presence of metal waves. If waves of liquid metal are present, consider increasing the value further with the estimated peak wave amplitude.

Try increasing the Pre-heating temperature (normally 100 °C) or the Pre-heating minimum time (normally at 120 s) if the probes still tend to break at immersion. Consider increasing this value if the analyzer is exposed to cold ambient temperature or cool air drafts.

Test this new configuration with the next probe immersion.

5.7.2.2 Configuring melt level tracking

The Melt level tracking should be kept enabled. One case where you may want to disable it is if the melt level in the

trough is so low that the electrode may rest at the bottom of the trough while measuring. In such case you have to stay by the system to monitor and control the system position relative to the melt level.

The Target tracking position needs to be adjusted any time the In-probe melt level detector is moved up or down to ensure that, during measurement, the tip of the In-probe melt level detector is a couple of mm above the outside melt level surface.

The Tracking mode controls how sensitive the system is to readjust the analyzer vertical position. You need to change the selection of this parameter when the melt level fluctuation rate is modified in the trough or, if the period or the amplitude of metal waves change. Select the item in the list that best match the situation. Watch how the system reacts to in-trough melt level variations. Try different selections until the analyzer can maintain its immersion without frequently readjusting its vertical position.

5.7.2.3 Configuring conditioning during first fill

The conditionings at first fill, both at 25 and 90% (normal) fill time, help ensuring that the first time the probe is filled goes smoothly. Deselect these parameters only if you have a reason to minimize or eliminate all conditionings.

5.7.3 Configuring the measurement parameters

In the Presets dialog box, click on Measuring on the left side. “Figure 37: Analyzer settings (Preset) - Measuring” on page 41 shows the available configuration parameters.

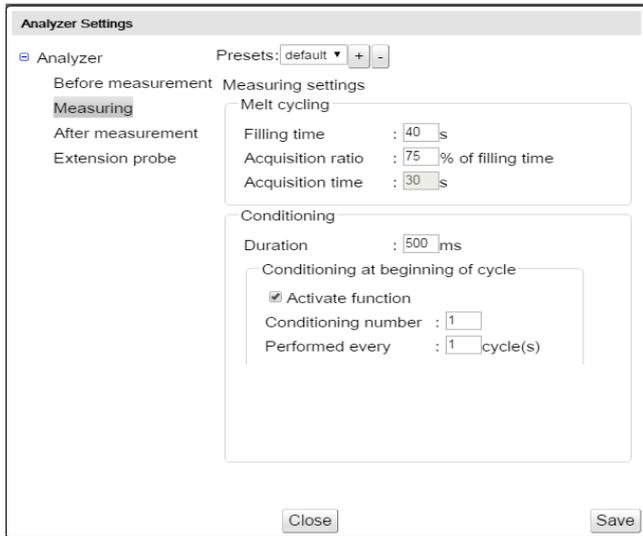


Figure 37: Analyzer settings (Preset) - Measuring

5.7.3.1 Configuring Melt cycling

The value of the Filling time parameter corresponds to the time interval over which the liquid metal is forced into the probe. The default value is 40 seconds.

Consider reducing Filling time value:

1. If you use an extension probe to ensure that fresh metal is sampled.
2. In the presence of micro-bubbles in the melt, if the ESZ baseline signal is degrading towards the end of the cycle.

It is not recommended to increase the Filling time value. If you do so, you then need to move up the In-probe Melt Level Detector and reduce the Target tracking position accordingly.



Attention - Important information

The duration of the liquid metal is expelled from the probe is also set by the Filling time parameter so a complete liquid metal sampling cycle is twice the Filling time parameter value.

change the Filling time parameter.

The Acquisition time is calculated from the Filling time and from the Acquisition ratio.

5.7.3.2 Configuring conditionings

There are several configuration parameters for the Conditioning function. Details for each parameter are given below. Refer to section 6.25 for more information on the Conditioning function.

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Parameter	Description	Default value	Recommendations
Duration	Duration of the ESZ automatic and manual conditioning current shots.	2/20 second	Increase value when several Conditionings within a cycle do not succeed in restoring a stable ESZ baseline signal. Note that longer Conditionings contribute to corrosion of the orifice so it is desirable to keep them short.
State (Conditioning at beginning of cycle - Activate function)	State of the “Conditioning at beginning of cycle” function. Automatically generates one conditioning at the beginning of each cycle when Enabled. Effective preventive function to automatically recondition the orifice after a change of liquid metal flow direction through the orifice.	Enable	Disable only if you need to eliminate or reduce to the minimum the number of conditionings. To ensure good ESZ signal baseline, an operator shall watch the signal from the oscilloscope window to validate it and manually apply conditionings when needed.
Conditioning number (Conditioning at beginning of cycle)	Number of ESZ conditioning current shots automatically applied at the beginning of every x cycles as configured in the Performed every parameter.	1	Increase if one conditioning is not successful in restoring the ESZ baseline signal. Note that each Conditioning contributes to corrosion of the orifice so it is desirable to reduce occurrence.
Performed every: (Conditioning at beginning of cycle)	Cycle interval where x ESZ conditioning current shots are automatically applied as configured in the Conditioning number parameter. For example, with a value of 4, a conditioning will be applied at the beginning of 1 cycle out of 4.	1	Increase value if you want to extend the life of a probe (useful for extended measurement period of continuous casting) when the metal is very clean and the ESZ hardly needs any conditioning.
Based on orifice obstruction diagnostic (Other automatic conditionings)	Automatic conditioning performed in series at regular intervals, starting when probe filling significantly exceeds normal fill time and terminating when in-probe melt touches the In-probe melt level detector.	Selected	Deselect only if you need to eliminate or reduce to the minimum the number of conditionings. To ensure normal termination of melt cycles, an operator shall watch the analyzer status and manually apply conditionings when needed.

5.8 Configuring the „terminating measurement“ sequence

In the Presets dialog box, click on Measuring on the left side. [Figure 38](#) below shows the available configuration parameters. In the console, position your cursor over a parameter label to get the parameter description.

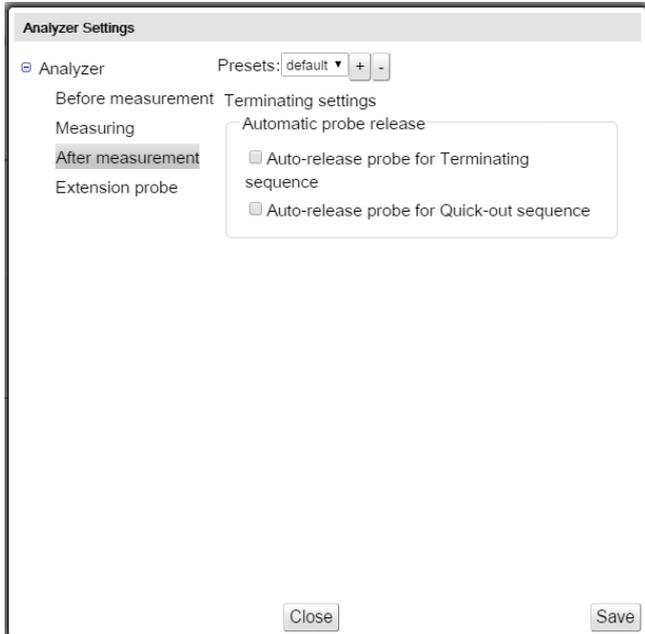


Figure 38: Analyzer settings (Preset) - After measurement

Detailed information on the Automatic Probe Release parameters is given below.

Parameter	Auto-release probe for Terminating sequence
Description	Enable automatic probe release during Terminating Measurement sequence when probe is empty before raising the analyzer. This eliminates the need for the operator to remove the probe.
Default value	Not selected
Recommendations	Select only if it is safe to leave the probe in the trough at the end of a measurement.
	 WARNING – Bodily injury Before using this function, make sure that the automatic expulsion of the probe in the trough is safe for your operation.

Parameter	Auto-release probe for Quick-out sequence
Description	Enable automatic probe release during quick-out sequence before raising the analyzer, even if probe is not empty. This is a useful function to eliminate the problem of left over liquid metal in the probe freezing on the electrode.
Default value	Not selected

Recommendations	Select only if it is safe to leave the probe in the trough at the end of a measurement.
	 WARNING – Bodily injury Before using this function, make sure that the automatic expulsion of the probe in the trough is safe for your operation.

5.9 Configuring the „Extension probe“ settings

Extension probes are used in the presence of micro bubbles. This probe type requires special setting. Refer to “Figure 39: Analyzer settings (Preset) - extension probe” on page 43 for settings that are specific to extension probes.

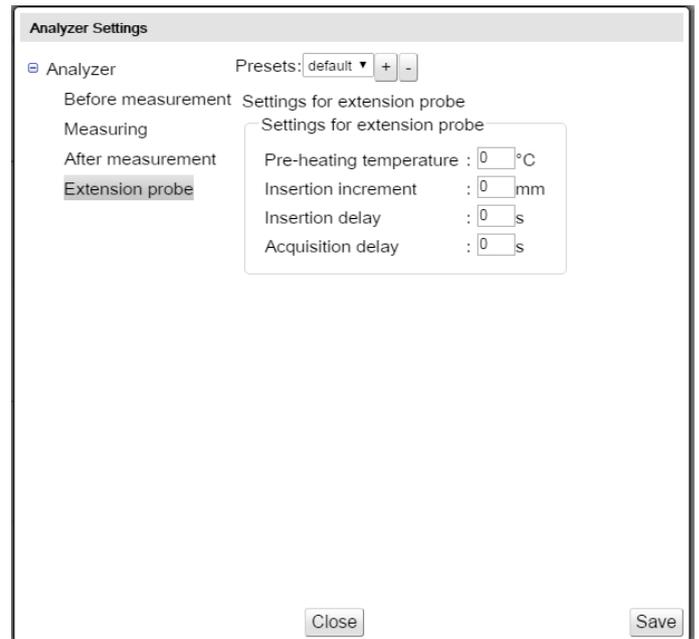


Figure 39: Analyzer settings (Preset) - extension probe

The default values for the extension probes are as follows:

Preheating temperature: 115 °C (239 °F)

Insertion increment : 8 mm (0.3 in)

Insertion delay: 8 sec.

Acquisition delay: 2 sec.

5.10 Software and/or firmware update

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When a new software or firmware version is available for the LiMCA III instrument, simply put the update on a USB key and proceed as follows.

1. Make sure the instrument is OFF.
2. Insert the USB key with the update in the USB port.
3. Start the analyzer and wait until it is ready (Ready button is solid white all the indicator become solid white).
4. Wait for 10 seconds or until the indicator on the USB key stops flashing (if applicable).
5. Remove the USB key.
6. Restart analyzer.
7. The new software and/or firmware version is installed.

6 Operating the system

6.1 Operation summary

This section offers a summary of system operation tasks. The list refers to other sections for more information on specific subjects.

1. Connect the analyzer (refer to sections [6.2.1 on page 45](#)).
2. Preparing for measurement
 - If not already done:
 - Power up the analyzer (see section [“6.2 Power up the analyzer” on page 45](#)).
 - Create new dataset and enter the cast details, refer to [“6.3 Create dataset” on page 46](#).
 - Install a probe in the mandrel (see section [“6.4 Installing a probe” on page 46](#)).
 - Note the probe orifice diameter and enter it in the software interface (see section [“6.4.1 Setting the orifice size from the web browser interface” on page 46](#)).
 - If applicable, position the analyzer at the measuring location, ready to start measurement.

3. Start the analyzer “Preparing for measurement” sequence using one of the following method:

Using the manual controls panel (see section [“6.6.2 Manual immersion and data collection initiation”](#)) and [“6.7 Starting measurement from the analyzer”](#).

From the web browser interface (see [“6.6.1 Automatic Immersion”](#))

4. During the measurement:
 - Review live results (see section [“6.20 Reviewing the measurement results from the web browser interface” on page 55](#)).
 - If needed, review analyzer status (see sections [“6.5.1 System verification” on page 47](#) and [“6.18 Viewing detailed analyzer status from the web browser interface” on page 53](#)).

5. Activate the “Terminate measurement” sequence using one of the following method:

Using the manual controls panel (see section [“6.8 Terminating measurement from the analyzer”](#) for normal termination and

section [“6.12 Quickly withdrawing the analyzer from the melt”](#) for quick termination).

From the software interface (see section [“6.9 To terminate a measurement from a remote connection:”](#)).

6. When the measurement is completed:
 - Close the dataset from the software interface (see section [“6.23 Closing a dataset from the software interface” on page 59](#)).

6.2 Power up the analyzer



WARNING – Property damage

Once the dolly is carried to its operating location, it is very important to activate the two stabilization bars in the front part of the dolly. This operation is essential to ensure a safe stability of the instrument at its operating location. It is also possible to position the LiMCA III instrument leaning on the trough that thus acts as stabilizer.

6.2.1 Connections and power on

Bring the LiMCA III instrument to its measuring location by the trough. Bring the LiMCA III computer to the selected location. Make the following connections

1. Connect the electrical power cord to the LiMCA III interface plate and to the power source.
2. Connect the compressed air hose to the LiMCA III interface panel. Turn the air supply ON. Make sure warm air comes out of the vortex exhaust of the instrument.
3. Connect the Argon hoses to the LiMCA III interface plate argon input. Turn the Argon supply ON.
4. Connect the Ethernet cable from the LiMCA III instrument to the LiMCA III computer (if desired)
5. Now that all connections are made, turn ON the power of the LiMCA III instrument. Wait for the boot sequence to complete. The Ready button is solid green.
6. Install the probe on the mandrel, refer to [“6.4 Installing a probe” on page 46](#)
7. Start the LiMCA III session. To verify status and if connection is established connect your computer (refer to

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“5.4 Network configuration” on page 36) to the LiMCA III. In the computer open a web browser and connect to the instrument by typing the IP address. Check if the main screen is displayed. Check for error messages.

6.3 Create dataset

In the LiMCA III program, click on Data and Create New Dataset or on the 4th icon on the left side of the main screen of the chart window selection.

- Enter a value for the Cast name. This is an important parameter in this page since its value is also used to name the file in which the data will be saved.
- Enter the processing information about the cast you are going to measure. Regular parameters already appear on the page. Just fill in the accompanying spaces. However, should you wish to include additional information, use the comments section. Any parameters you enter for a given cast are kept for the next one, so you do not have to re-enter all this information for subsequent casts.

6.4 Installing a probe

The probe support of the LiMCA III analyzer is equipped with a probe insertion detector. The detector consists of a spring-loaded pin located in the mandrel that activates two switches when pushed by an inserted probe. The Analyzer automatically grabs the probe when the operator inserts the probe in the mandrel. The probe button indicator on top of the LiMCA III head flashes when a probe is inserted and stays lit when the probe is fully inserted and grabbed.

To install a probe:

1. Carefully slide the probe around the in-probe components (in-probe electrode and In-probe melt level detector) and fully insert it up in the mandrel.
2. Verify that the instrument has grabbed the probe, confirming that the Probe button indicator on the LiMCA III head is ON.



Attention - Important information

The status indications and the probe image appear only when a probe is inserted in the LiMCA III head mandrel and is properly grabbed.

6.4.1 Setting the orifice size from the web browser interface

The orifice size (diameter) of the probe is a key parameter in the size evaluation of the inclusion detected by the LiMCA III electric sensing zone. The nominal orifice size of the probe is 300 μm but the orifice diameter of production probes may vary between 290 to 310 μm . The orifice diameter is measured individually for each probe and its value is engraved on the probe.

When a probe is inserted in the mandrel, the software automatically resets the probe orifice diameter value to 300 μm .

It is the operator's responsibility to read the orifice size marked on the installed probe and enter the information in the Probe configuration dialog of the console application.



Attention - Important information

Failing to enter the correct orifice size diameter value causes an error of up to 4.5% on the inclusion diameter measurement.

To set the orifice size from the console:

1. If the Probe Configuration dialog box (see “Figure 40: Probe configuration dialog box” on page 46 below) is not already open following the installation of a probe, select Probe Configuration... from the Tools menu.

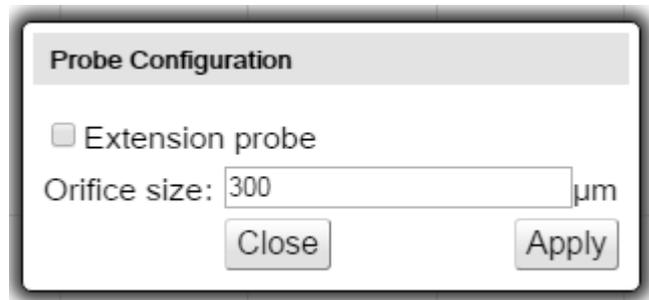


Figure 40: Probe configuration dialog box

2. Select the size written on the probe from the Orifice size pull-down menu. If you don't know the size, leave the value to 300 μm , leading to the lowest probability of error.
3. If you are using a different type of probe (such as an Extension probe) select the appropriate type from the

Probe type pull-down menu.

4. Click OK to make changes effective.



Attention - Important information

The server automatically resets the probe orifice size to 300 µm each time that a probe is installed in the mandrel.

6.4.2 Select Preset

When the initialization is finished, click on Presets to select the instrument's configuration.

- The default preset is loaded or pick the appropriate operation preset for the measuring location or condition. If an Operation preset is not available for this condition, make the appropriate changes to the parameters that can be saved for future use. Refer to section “5.9 About analyzer configuration presets” on page 51 for more details. Do not change a field parameter if you do not fully understand its function.
- Find the orifice diameter of the probe that you will install. Click on Analyzer menu and Probe configuration and type it in the field of the “Orifice size” parameter.

6.5 Initial position



WARNING – Property damage

If you use the Automatic immersion sequence, the instrument must be positioned in a proper initial position. It is the responsibility of the operator to position the LiMCA III instrument in a manner that allows the head to move freely and the probe to reach the melt. This is referred to as the “initial position”.

The “initial position” is the physical location of the dolly as well as the height and the angle of the LiMCA III body of the instrument.

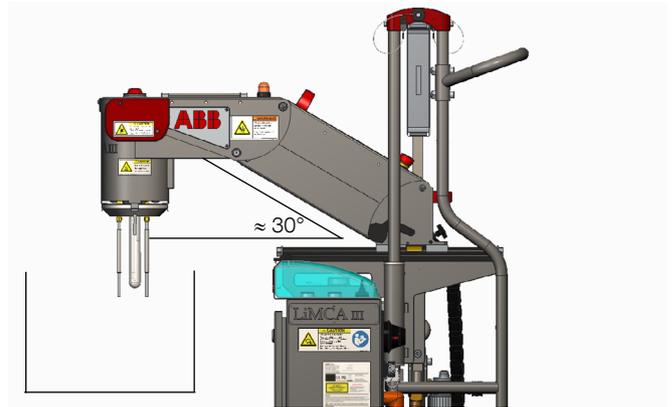


Figure 41: LiMCA III initial position

For each location where the Automatic LiMCA III instrument will be operated, the technical person in charge of the system must identify the optimal initial position for the instrument. The optimal initial position should be documented and the information transferred to the LiMCA III operators.

Factors to consider when identifying the Optimal Initial position are (refer to “Figure 41: LiMCA III initial position” on page 47):

- The LiMCA III head can move down freely without touching surrounding objects (trough walls, pipes, etc...).
- The LiMCA III head must also be able to rise freely to its upper position.
- The angle of LiMCA III neck should ideally be at least 30 degrees from horizontal. Remember that the LiMCA III neck can bend up to 90° from its upper position.
- To help operators remember an optimal initial position at a frequent measuring location, it is recommended to mark the LiMCA III dolly position on the floor. Similarly, the height and the angle of the LiMCA III head can be marked on the dolly.

6.5.1 System verification

Before taking any measurements of the liquid metal, follow these steps:

- Go to the Analyzer menu and select Detailed Status and verify that all temperatures are normal.
- Make sure the air-cooling system is turned on.
- Check the electrodes for breakage and then tighten them.

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- Make sure that the START button on the LiMCA III manual controls interface (left) is lit (solid white not blinking).
- Verify in the graphical analyzer status window (on the probe image) to see that the pressure around the probe is stable. If it is not, refer to section “8.8 Replacing the probe seal” on page 66 of this manual.
- Using the UP/DOWN knob on manual controls interface (left), press and the button downwards and see that the head moves down.
- On the manual controls interface, press the PRESSURE button to create a positive pressure inside the probe. You should be able to feel the gas forced out, by placing your finger in front of the small opening of the tube. Also, check the pressure reading on the main page of the computer or in the Detailed Status page (under Analyzer menu).
- On the manual controls interface, press the VACUUM button to create a negative pressure inside the probe. Check the vacuum reading on the “main” page or in the Detailed Status page (under Analyzer menu). You may see a warning message after a while concerning the vacuum because there is no current between the electrodes when the probe is not in the metal. This is normal.



WARNING – Property damage

In Manual Mode when applying vacuum, the in-probe melt level detector is not activated. Make sure to have a direct contact with the metal level inside the probe to manually put the instrument to atmosphere or pressure before the metal touches the in-probe melt level detector.

- Set the system to ATMOSPHERE by pressing the Atmosphere button on the manual controls interface.

If you have run through all the previous steps successfully, the verification of the system is finished, and you are ready to run LiMCA III over liquid metal.

6.6 Starting a measurement sequence

6.6.1 Automatic Immersion

The automatic immersion sequence should be used when your LiMCA III instrument is operated in a routine location

and conditions. The automation of the sequence greatly simplifies the operation.

Here we assume that the instrument is in an appropriate initial position, as described in section “6.5 Initial position” on page 47, and that all verifications listed in section “6.5.1 System verification” on page 47 have been done.

When liquid metal is in the trough where the LiMCA III instrument is installed and you are ready to start a measurement, simply press the Start button on the manual controls interface or the Start button in the web browser interface. Now just watch the instrument. Following the chosen preset (refer to “5.7 About analyzer configuration presets” on page 39, the system will:

- Bring the probe to its pre-heating position.
- Pre-heat the probe.
- Submerge the probe.
- Establish the electrical current.
- Fill the probe with metal a first time.
- Start the data acquisition in AUTO mode.

In the dataset page (click on the 4th icon on the left side of the main screen of the chart window selection), you may want to enter the real Start cast time. If it is not entered manually, the Start cast time is automatically set to the time at which the first data point is recorded.

6.6.2 Manual immersion and data collection initiation

A measurement sequence can also be started manually. You will want to use this method in special or new cases where the automatic immersion sequence is not appropriate. Examples of such special cases could be measuring in the head of an ingot, or when you want to start a measurement very quickly right at the beginning of the cast.

To start a measurement manually:

- Position the instrument over the launder using the dolly, and adjust the height and the angle of the instrument. Normally, the instrument should be placed so that its head is 6 to 8 inches (15 to 20 cm) over the liquid metal in the middle of the launder. Take a minute to clean the skim on the surface of the metal.
- Set the system in PRESSURE by pressing the Pressure button on the manual controls interface.

- Go to the Dataset page (click on the 4th icon on the left side of the main screen of the chart window selection) and type in the cast name. You may then enter the start cast time.
- Enter the orifice size in the probe configuration dialog box in the Analyzer menu. The size of the orifice is written on the glass tube itself.
- The high temperature Aluminosilicate probes must be preheated otherwise they may brake by thermal shock:
- Position the probe one inch (2.5 cm) over the surface of the metal and let it warm up for one or two minutes. A good rule of the thumb is also to wait until the “metal thermocouple” reads 100 °C.
- Position the probe on the surface of the liquid metal and stay there for another minute.
- Immerse the tube into the metal one inch (2.5 cm) and set the system to vacuum using the VACUUM button on the manual controls interface.

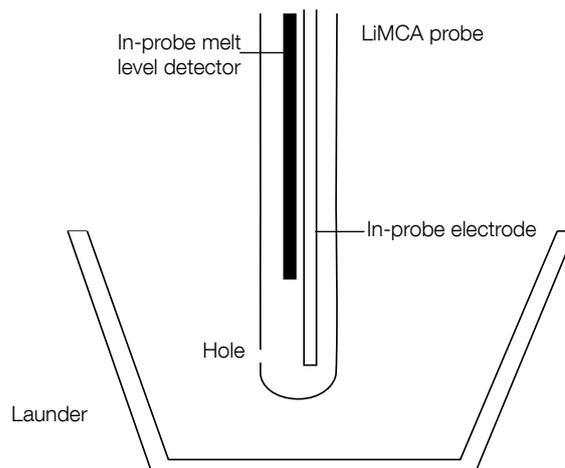


Figure 42: Probe level positioning in the launder



WARNING – Property damage

In Manual Mode when applying vacuum, the in-probe melt level detector is not activated. Make sure to have a direct contact with the metal level inside the probe to manually put the instrument to atmosphere or pressure before the metal touches the in-probe melt level detector.

- If the metal does not properly enter the tube, press the PRESSURE button for 2 or 3 seconds, and then return to VACUUM.
- Very slowly, continue to insert the probe into the metal using the manual control up/down knob. The probe should be inserted until the lower end of the metal thermocouple is at the surface-level of the metal (see Figure 42). Insert the probe at the rate of 1/2 inch (1 cm) per 15 seconds.

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6.6.3 Adding comments to a dataset

During a measurement it is possible to add comments to note special events or any pertinent events. Simply click on the 5th icon on the left side of the main screen of the chart window selection. The comments window is displayed. In the bottom part enter the Author and the comment.



Attention - Important information

Both fields, i.e. author and comment have to contain information. Otherwise the data is not registered.

6.7 Starting measurement from the analyzer

To start a measurement from the analyzer:

1. Make sure a probe and all other consumables are installed and in good condition.
2. Make sure the LiMCA III analyzer is placed appropriately at the measuring location. Verify that the analyzer is in a position where it can reach the melt using only its built-in positioning mechanism movement.
3. Press the Start button (located at the manual controls interface on the left side).

As soon as the Start button indicator is ON the analyzer is ready for measurement indicating that the “Before measurement” sequence is complete. The analyzer moves down close to the melt to preheat the probe, immerses the probe and, fills the probe a first time before starting the measurement sequence. The Start button indicator is now Flashing indicating the analyzer is measuring.

If the instrument control alarm indicator flashes, consult the status and log messages from the software interface to understand the cause of the alarm.

6.8 Terminating measurement from the analyzer

The normal termination of a measurement session allows for emptying the probe before withdrawing the analyzer from the melt. This prevents cases where liquid metal freezes in the probe around the electrode when withdrawn from the melt.

To terminate the measurement from the analyzer:

4. Make sure a pair of probe pliers is available at the analyzer.

5. Press the Stop button twice (instrument control interface on the left side).
6. The Stop button indicator flashes indicating that the “Terminate measurement” sequence is active. The analyzer first empties the probe before rising all the way to its upper rest position.
7. When the used probe is out of the melt, grab the probe with the probe pliers and press the Probe button on top the LiMCA III head to release the probe.
8. Carefully slide down the probe away from the inner electrode and in-probe melt level detector. Safely dispose of the used probe.

If the alarm indicator on top of the LiMCA III head flashes, consult the status and log messages from the web browser interface application to understand the cause of the alarm.

6.9 To terminate a measurement from a remote connection:

1. Make sure a pair of probe pliers is available at the analyzer.
2. Press the Stop button in the Graphical Analyzer Status window (see “[Figure 43: Terminate measurement phase “emptying probe”](#)”).
3. The different phases of the “Terminate measurement” sequence are progressively shown in “[Figure 43: Terminate measurement phase “emptying probe”](#)” below.
4. The “Terminating measurement sequence first empties the probe
5. After the probe is empty, raises the analyzer to withdraw the probe from the melt
6. Stops rising when analyzer reaches upper rest position. Analyzer then Ready with a used probe.

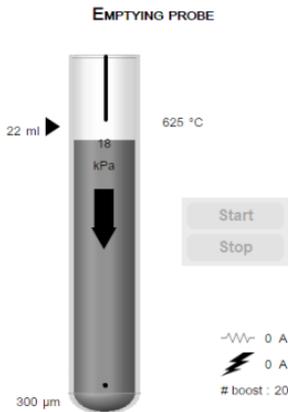


Figure 43: Terminate measurement phase “emptying probe”

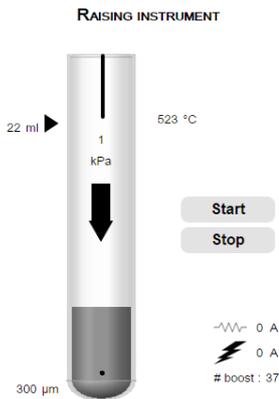


Figure 44: Terminate measurement phase raising instrument

7. When the used probe is out of the melt, grab the probe with the probe pliers and press the Probe button (on the analyzer head) to release the probe.
8. Carefully slide down the probe away from the inner electrode and in-probe melt level detector. Safely dispose of the used probe.

If the indicator flashes, consult the status and log messages from the console application to understand the cause of the alarm.

6.10 Remove the probe from the analyzer

To remove the probe from the analyzer:

1. Grab the probe with appropriate tool (pliers or glove).
2. Press the Probe button and keep pressed (on top of the head) on the analyzer control panel to release the probe.
3. Carefully slide down the probe away from the inner electrode and in-probe melt level detector. Safely dispose of the used probe.

6.11 Activating emergency stop

The Emergency Stop button (big red button located on the neck) is used to stop and prevent all vertical movement of the analyzer. This function is needed and shall be used to safely work around the analyzer, ensuring that it will not start moving as automatic sequences are remotely initiated.

To stop and prevent all vertical movement of the analyzer:

1. Press the emergency stop button.
2. Do not forget to pull out the button when the emergency stop safety condition is cleared.



Attention - Important information

Pressing the emergency stop button stops all analyzer vertical movements and aborts any ongoing sequence of operation. It will also prevent other sequences of operation from starting. Both cases generate alarm events.

6.12 Quickly withdrawing the analyzer from the melt

In some conditions you may need to immediately withdraw the analyzer from the melt.

To quickly withdraw the analyzer from the melt:

1. Make sure a pair of probe pliers is available at the analyzer.
2. While the analyzer is in the melt, if safely possible, grab the probe using probe pliers.
3. Press the Probe release on top of the LiMCA III head.
4. The Probe release button turns OFF indicating the probe is released. The Stop button indicator flashes indicating that the “Terminate measurement” sequence is active. The analyzer rises all the way to its upper rest position.

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5. Carefully slide down the probe away from the inner electrode and in-probe melt level detector. Safely dispose of the used probe.

The probe may contain a fair amount of liquid metal. Safely dispose of the used probe.

If the alarm indicator on top of the LiMCA III head flashes, consult the status and log messages from the web browser interface application to understand the cause of the alarm.

6.13 Stop all analyzer sequences from the analyzer

You can terminate all analyzer sequences to bring the analyzer in an idle mode, ready to operate but not necessarily at its upper rest position.

To stop all analyzer sequences:

1. While the “Before measurement” or the measurement sequence is active, press the Stop button twice (instrument manual control interface on the left side). This aborts the sequence and starts the “Terminate measurement” sequence.
2. Press the Stop button again to abort the “Terminate measurement” sequence. Pressing the STOP button will pause the termination sequence. But the termination sequence cannot be aborted.
3. The analyzer stops any vertical movement and falls in the Ready mode.

6.14 About routine analyzer verifications

The personnel operating the LiMCA III analyzer should perform the following routine verifications of the analyzer:

- Verify that the five electrodes are in good condition and tightly screwed in the mandrel.
- Verify that the maximum immersion detector is present and tightly screwed in the mandrel.
- Verify that the in-probe melt level detector thermocouple is in good condition and its tip well coated (using boron-nitride or other non-wetting coating) to prevent freezing metal from sticking to the thermocouple tip.
- Verify that the laser window and compartment are clean.

6.15 Shutting down the analyzer

When the analyzer is not used, store it in a safe area. Do not leave the analyzer powered OFF while exposed to the harsh plant environment, as it will not be able to control its internal cooling. Note that when powered ON, air flows to the vortex devices of both the analyzer and the head, thus providing full cooling to the system.

To shut down the analyzer:



WARNING – Property damage

Make sure all analyzer sequences have been properly terminated, refer to [“6.8 Terminating measurement from the analyzer”](#) on page 50.



WARNING – Property damage

This procedure does not ensure zero energy in the LiMCA III analyzer. Always perform the zero energy procedure before servicing internal analyzer components.

1. Turn OFF the main power switch of the analyzer (located on the connection panel).
2. Wait until the control panel POWER, READY and NETWORK indicators are OFF.

6.16 Launching the web browser interface application

Open a web browser (Firefox® or Chrome™) and enter the following address: 10.127.127.127. The default IP address can be changed or retrieved, refer to [“9.3.1 Retrieving IP address”](#) on page 68 and [“9.3.2 Changing IP address”](#) on page 68.

The LiMCA III main window is displayed.

6.17 Viewing basic analyzer status the web browser interface

The status of the analyzer is shown in the Graphical Analyzer Status window (see [“Figure 45: Graphical Analyzer Status window \(measuring status\)”](#) on page 53 below) in the top right corner of the web browser interface screen. Refer to Section [“3.9 LiMCA III web browser interface overview”](#) on page 23 for an overview of the web browser interface main screen.

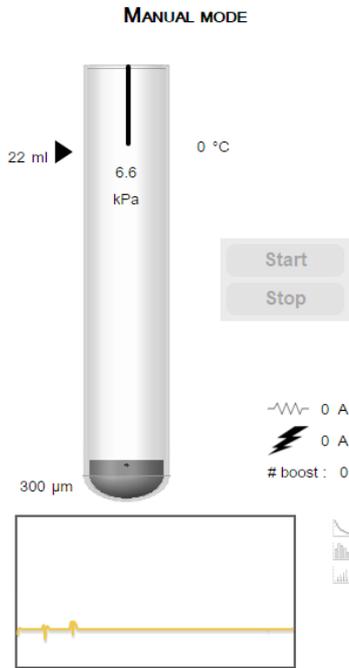


Figure 45: Graphical Analyzer Status window (measuring status)

The window provides:

- State of the analyzer and the various sequences of operation.
- Various status parameters related to the electric sensing zone.
- Use Manual Controls to start the “Before measurement” sequence and to initiate the “Terminate measurement” sequence.



Attention - Important information

The status indications and the probe image appear only when a probe is inserted in the LiMCA III head mandrel and is properly grabbed.

6.18 Viewing detailed analyzer status from the web browser interface

You can view all available analyzer status parameters from the status window. To access the status window, select Detailed Status from the Analyzer menu. The LiMCA III-Analyzer status windows are shown in “Figure 46: LiMCA III-Analyzer Detailed status window” on page 53.

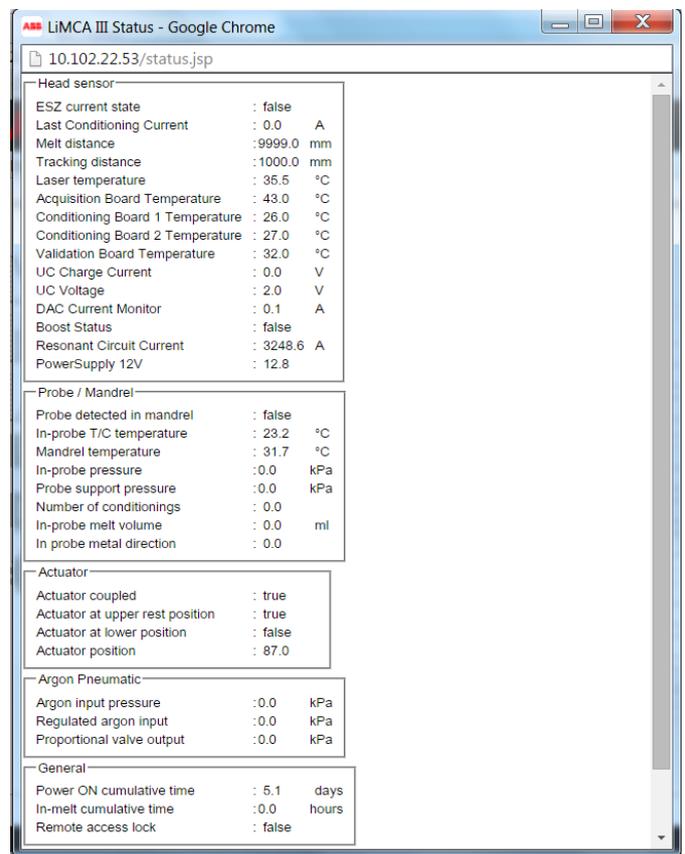


Figure 46: LiMCA III-Analyzer Detailed status window

6.19 Starting a measurement from the web browser interface

To start a measurement from the console:

1. Make sure a probe and all other consumables are installed and in good condition.
2. Verify that the analyzer is in a position where it can reach the melt using only its built-in movement.
3. Press the Start button in the Graphical Analyzer Status window (see “Figure 45: Graphical Analyzer Status

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window (measuring status)” on page 53).

- The different phases of the “Before measurement” sequence are progressively shown in Figure 47 to Figure 49.

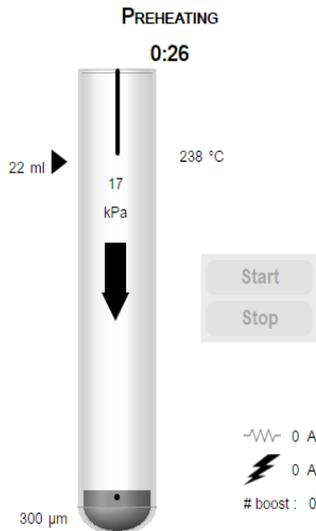


Figure 47: Positions the probe just above melt for preheating period

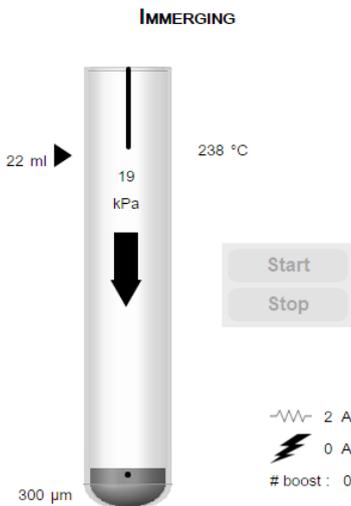


Figure 48: After completion of preheating, immerses probe

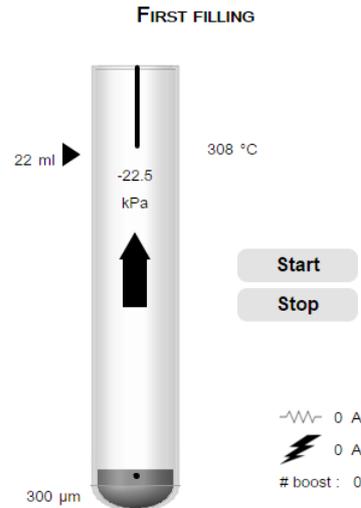


Figure 49: After probe immersed, sets vacuum in probe to start filling the probe for the first time

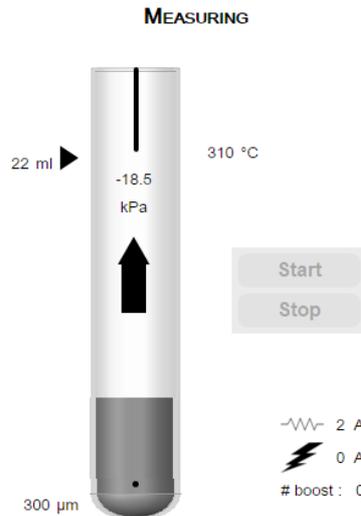


Figure 50: After probe filled for the first time, starts measuring cycling

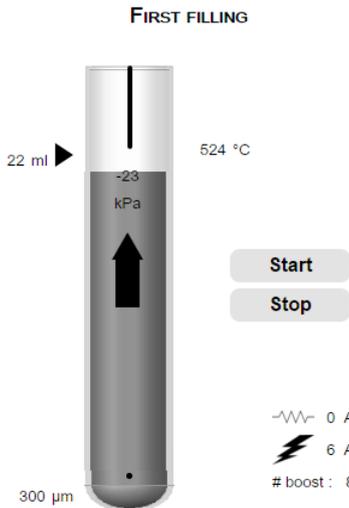


Figure 51: After a manual pause, the probe is filled again

6.20 Reviewing the measurement results from the web browser interface

With new sample data acquired every minute, the LiMCA III provides a unique real-time at-line inclusion concentration measurement allowing you to follow inclusion concentration trends and transients.

You can review the LiMCA results during the measurement sequence or after you terminated the sequence. You can also review the results of a closed dataset. In this case, you first need to open the dataset (see “7.2 Reviewing an archived dataset” on page 61).

The LiMCA III system produces inclusion concentration data and presents it various graphical and numerical views. The basic data is an inclusion size distribution per unit of sampled liquid metal from which the system calculates various inclusion concentration indicators (refer to section “3.6 About inclusion concentration indicators” on page 22 for details).

For each metal sample the LiMCA III system:

1. Detects and measures the equivalent spherical diameter of each inclusion passing through the ESZ (orifice of the probe).
2. Generates particle size distribution data (visualized on the Histogram view) and calculates the various inclusion concentration indicators (visualized on the Time Display and Sample Review screens).

3. Updates the Time display view with the selected indicator value.

6.20.1 Reviewing data from the Time Display

The Time Display provides a graphical view of the selected inclusion concentration indicator, thus showing the inclusion concentration trend. As shown in “Figure 52: Reviewing data from the Time Display” on page 55, the Time display provides several other types of information. For more information on the validation criteria refer to section “5.11 About validation criteria” on page 63.

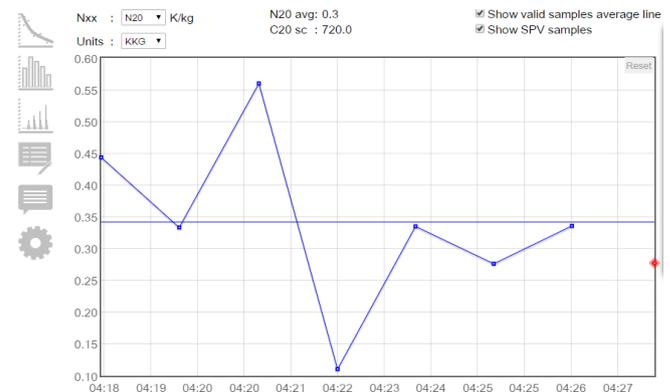


Figure 52: Reviewing data from the Time Display

Use the Time Display to:

- Look for sudden inclusion concentration transients.
- Compare inclusion concentration indicator trend with other casting parameters to help in identifying sources of inclusions.
- Compare inclusion concentration levels and trends amount several casts in similar condition:
 - To identify the best practices
 - Optimize casting equipment operation (holding furnace, filter, degasser) and casting practices.

6.20.2 Reviewing data from the Histogram

The Histogram provides a graphical view of the inclusion size distribution for the selected inclusion concentration indicator and for the selected sample (or average of samples). “Figure 53: Reviewing data from the Histogram” on page 56 shows the various Histogram functions. Reviewing the histogram of various samples is useful to become aware of typical and unusual detected inclusion sizes.

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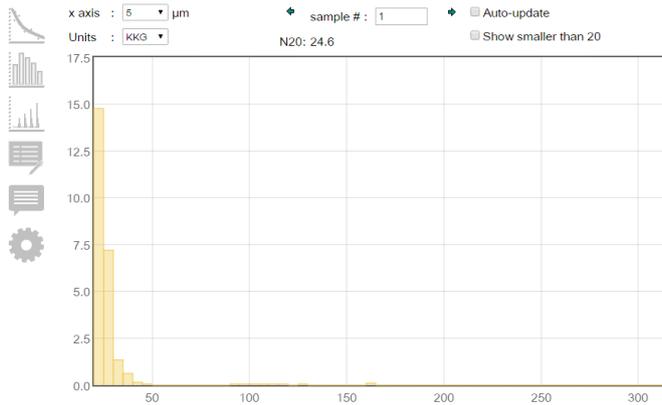


Figure 53: Reviewing data from the Histogram

6.21 Terminating a measurement from the web browser interface

To terminate a measurement from the console:

1. Make sure a pair of probe pliers is available at the analyzer.
2. Press the Stop button in the Graphical Analyzer Status window to pause the measurement and press Stop again to complete the termination sequence (see "5.8 Configuring the „terminating measurement“ sequence" on page 42).
3. The different phases of the "Terminate measurement" sequence are progressively shown in Figure 7 16 below.

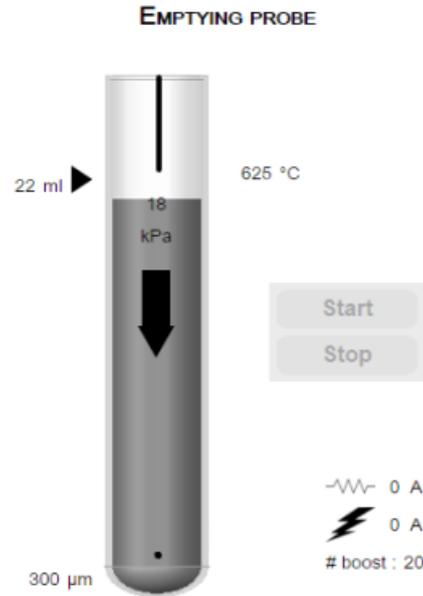


Figure 54: The "Terminating measurement sequence first empties the probe

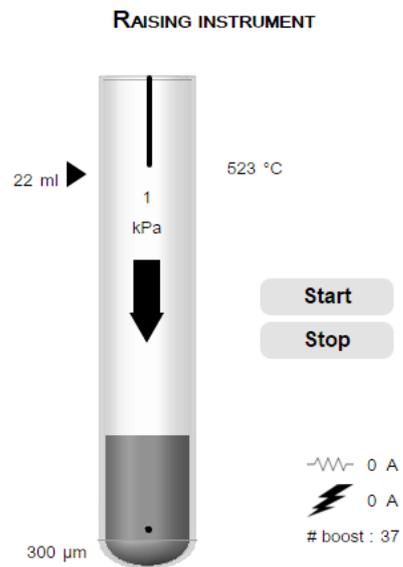


Figure 55: After the probe is empty, raises the analyzer to withdraw the probe from the melt

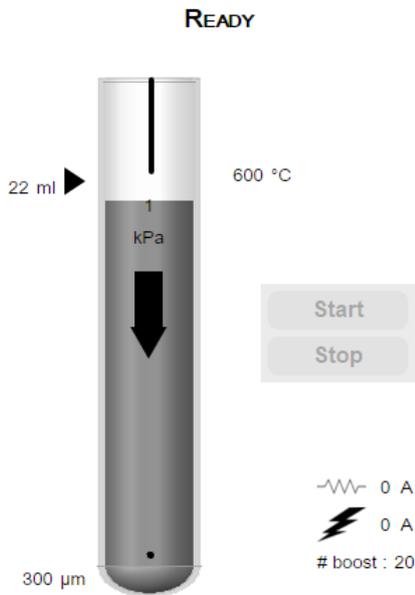


Figure 56: Stops rising when analyzer reaches upper rest position. Analyzer then Ready with a used probe.

4. When the used probe is out of the melt, grab the probe with the probe pliers and press the Probe button (probe down-arrow pictogram) on the analyzer control panel to release the probe.
5. Carefully slide down the probe away from the inner electrode and in-probe melt level detector. Safely dispose of the used probe.

If the alarm indicator on top of the LiMCA III head flashes, consult the status and log messages from the web browser interface application to understand the cause of the alarm.

6.23 Closing a dataset from the software interface

The dataset is closed when a new dataset is created.

6.24 Selecting a configuration preset from the web browser interface

The LiMCA III web browser interface provides a method to create presets of analyzer configuration parameters. Selecting a preset is the easy way to quickly recall a given analyzer configuration without having to verify all the analyzer configuration parameters.

To select a configuration preset:

1. Click on the Presets menu and choose import presets.

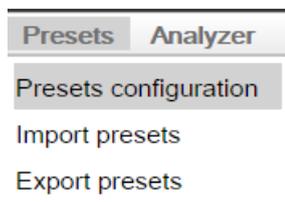


Figure 58: Preset choice dialog box

2. In the Preset choice dialog box click Choose file. Browse for the file of the preset and click Open (see “Figure 58: Preset choice dialog box” on page 59).

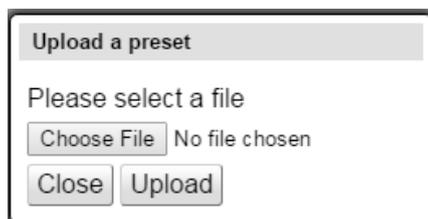


Figure 59: Upload Preset dialog box

6.25 About ESZ conditioning

The Electric Sensing Zone (ESZ), the probe orifice in presence of an AC electric current, needs to be well conditioned to produce a good signal. A well-conditioned orifice is clean and has wall surfaces wetted by liquid metal leading to a laminar flow of liquid metal.

The orifice walls of the glass probe are not naturally easily wetted by liquid aluminum. This tends to produce turbulent liquid metal flow through the probe orifice and causing noise on the signal baseline, thus preventing detection of small pulses associated with small inclusions. Presence of inclusions in or near the orifice may have the same effect.

A conditioning shot is a short application (fraction of a second) of high electrical current (few hundred amperes) to the electric sensing zone (ESZ) to favor cleaning and wetting of the orifice by the liquid metal. Regular application of conditioning shots is a key process to maintain a stable ESZ signal.

Refer to section 5.7.3 to configure automatic conditionings and to section 6.26 manually generate configuration shots.

6.26 Applying a condition shot at the ESZ

The LiMCA III analyzer is generally configured to systematically regularly and intelligently apply conditioning shots to the ESZ. You may also manually apply conditioning shots when you judge that the ESZ signal stability is not good (refer to section “6.29 Validating the electric sensing zone signal from the web browser interface” on page 60 for information how to judge the ESZ signal state).

To apply a conditioning shot to the ESZ:

1. Press the Conditioning button on the manual controls interface.

In the Graphical Analyzer Status window (see “Figure 45: Graphical Analyzer Status window (measuring status)” on page 53, the orifice of the probe will temporarily appear in red and the Cond. parameter will increment, indicating the cumulative number of conditioning shots applied to the ESZ since the installation of this probe.

6.27 Listing active alarms

The analyzer may be in an alarm state resulting from one or many abnormal conditions. The List of active alarms function accessible when clicking on the Last Log Entry (on the bottom left of the interface) provides a list of all the currently active alarms, thus allowing to easily identify the causes of the alarm state.

To get the list of active alarms:

1. Click on the Last Log Entry (on the bottom left of the interface).

The active alarms window, shown in Figure 60, appears providing a list of the currently active alarms and their reset condition. Each line is related to one alarm condition.

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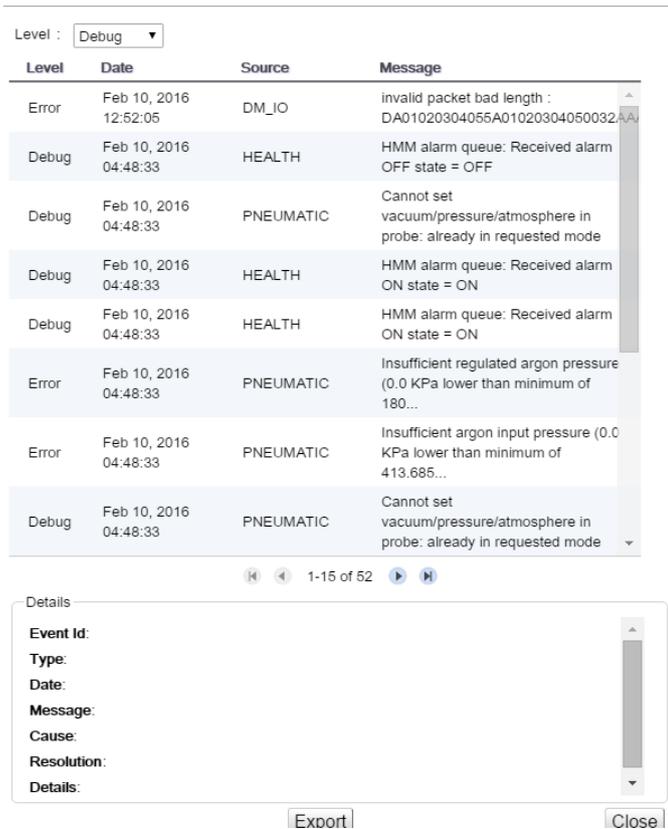


Figure 60: Active alarms window

- Click the Close button in the bottom right corner of the window to close the window.

6.28 Alarm behavior

Various conditions can cause an alarm to be set. In many cases, the analyzer automatically resets (turn OFF) the alarm when the conditions leading to the alarm state resolve.

6.29 Validating the electric sensing zone signal from the web browser interface

The electric sensing zone (ESZ) is the heart of the LiMCA technology. The orifice of the probe, in the presence of electric current, becomes the electric sensing zone. Each inclusion passing through the orifice with the liquid metal flow temporarily increases the orifice resistance, thus producing a voltage pulse.

You can visualize the live electric sensing zone with the oscilloscope window while the analyzer is sampling liquid metal in Measuring mode.

To view the live electric sensing zone signal, select Oscilloscope ... from the View menu to make the small oscilloscope window visible at the lower left corner of the console main screen.

To look at the electric sensing zone signal more closely, select Oscilloscope ... from the Tools menu to open the full Oscilloscope window (see “Figure 61: LiMCA III- Oscilloscope” on page 60 below). Resize the window and adjust the Scales and Trigger parameters as needed to view the signal.

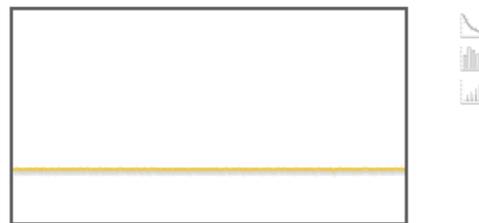


Figure 61: LiMCA III- Oscilloscope

The electric sensing zone baseline is the flat line signal between pulses, corresponding to the flow of clean liquid metal. The baseline can become noisy if the wetting between the liquid metal and the orifice wall is not good or if the orifice is dirty.

A good electric sensing zone signal has a flat baseline with fluctuation not exceeding ± 0.05 mV on the oscilloscope screen (see Figure 61 above).

If the signal is wavy or oscillating with amplitude above ± 0.1 mV, consider applying a conditioning shot (refer to Section “6.26 Applying a condition shot at the ESZ” on page 59).

7 Managing LiMCA III data

7.1 About datasets

The data acquired by the LiMCA III system over a measurement session, typically over a cast, are organized as a dataset. A dataset contains detailed data relative to each metal sample as well as basic contextual session information. You can see the complete dataset structure using the Data/Previous data window (see section “7.2 Reviewing an archived dataset” on page 61).

These datasets are saved on the computer of the LiMCA III instrument. A dataset remains active until a new dataset is created. Following the creation of a new dataset, the software application packages the information contained in the live dataset folder adding contextual information for the session, writes the data to a file in the data folder using the Dataset ID parameter string as its name.

The native format for LiMCA III dataset files is CSV.

7.2 Reviewing an archived dataset

To review an archived dataset file stored on the LiMCA III instrument:

1. Select Previous Dataset from the Data menu.

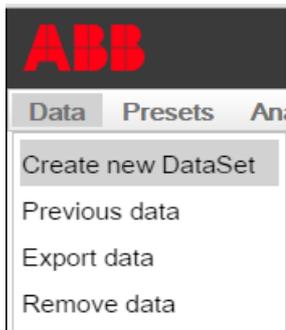


Figure 62: Previous Dataset dialog box

2. In the Previous Dataset dialog box, select File to access native LiMCA III files stored on the LiMCA III instrument,
3. In the file browser dialog select the file you want to review and click Open. A chart-window opens in the console application with the data of the opened dataset. All the time display, histogram and sample review functions are available.

7.3 Renaming an archived dataset

You may want to rename a dataset already saved on instrument or exported to an external computer. For example, if a dataset was originally archived under an automatically attributed dataset ID (yyyy.mm.dd-hh.mm.ss ID format), you need to rename the dataset to the real cast number.

The rename function changes both the filename and the internal dataset ID value in the file.

To rename an archived dataset:

1. Select Previous data from the File menu.

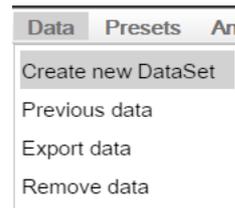


Figure 63: Rename Dataset dialog box

2. The open dataset dialog opens. Choose the dataset to modify.



Figure 64: Open existing dataset

3. In the cast name space, edit or type the new dataset ID and click OK.

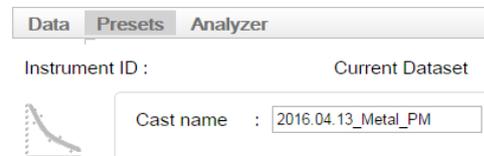


Figure 65: Input dialog box

4. The name is updated in the database.

7.4 Reviewing LiMCA III log events

To review live LiMCA III log events that occurred since the log repository was purged, in the main console screen, simply click on the gray title bar of the log section to maximize the log viewer window (example shown in “Figure 66: Log review window” on page 62).

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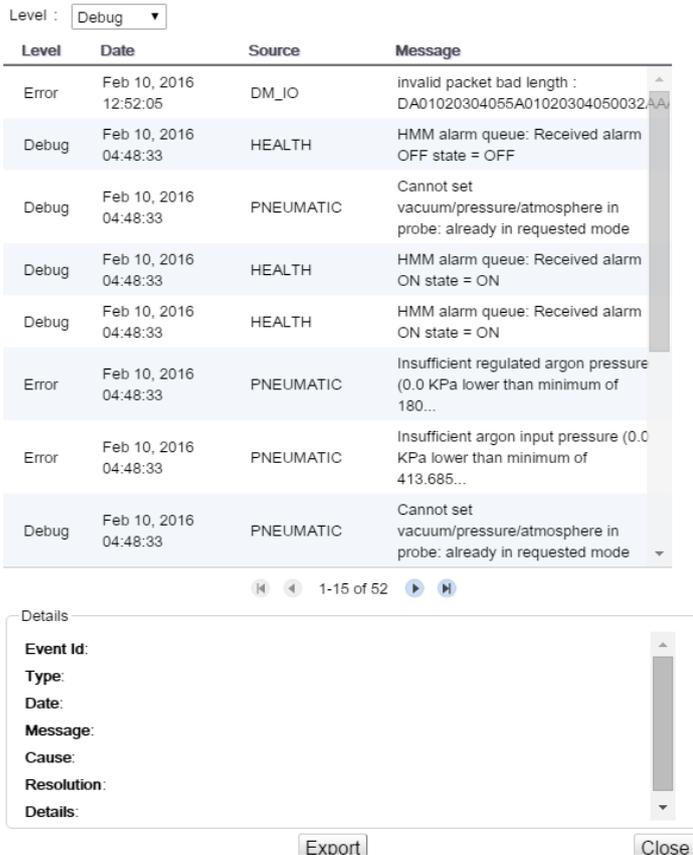


Figure 66: Log review window

In the maximized log window you can:

- View all log fields (column).
- Click on a log line in the table to see detailed description of the event in the lower section of the window.
- Select which log levels are displayed in the log table from the Log level menu.
- Sort the log table for any column by double-clicking on the column header.
- View the number of logs in the status bar at the bottom of the window.

Log files are all saved on the LiMCA III instrument. From time to time it is recommend to export log files.

To export log files, proceed as below:

1. Click on the Export button at the bottom of the maximized log window.
2. In the Save dialog box, browse for the location where

to save the .csv file, give the file a meaningful name and click Save.

The exported file is a zip file that has to be unzipped.

To review archived log files, simply double-click on the log file that opens in Excel.

7.5 Exporting dataset in CSV format

Live and archived datasets are stored in LiMCA III instrument. You may want to make copy of a dataset file to a local or network folder by copying the file. The LiMCA III dataset native file format is CSV.

To export a dataset:

1. Select Export dataset from the data menu.
2. In the Save dialog box, select the filename for saving the file and click Save.

7.5.1 Disc space

The files produced are rather small, even during long casts. Nonetheless, it is recommended to archive regularly the files. Should the hard disc become full, no specific error message is generated. See above procedure.

7.6 About time zones

All LiMCA III data that include date & time values is saved in CSV files in as Universal Time Code (UTC) format. In this format, the date time values are that of Greenwich and are an absolute time value.

8 System maintenance

8.1 Compressed air supply

The LiMCA III analyzer uses compressed air to cool the internal components. The supplied compressed air passes through a vortex cooling device and the vortex cooled air is blown in the analyzer and the LiMCA III head.

Establish a maintenance schedule of your compressed air supply equipment to ensure that you respect the compressed air supply specifications (see [Table 6 on page 63](#) below).

Table 6: Analyzer compressed air supply specifications

Specifications	
Maximum temperature	40 °C (104 °F)
Input pressure	552 kPa, 80 PSIG
Maximum input pressure	1400 kPa, 200 PSI
Flow at 552 kPa (80 PSIG)	481 SLPM, typically 17 SCFM (max. 25 SCFM)
Filter	0.3 µm
Oil content	Oil free
Dew point	-40 °C (-40 °F)



WARNING – Property damage

Failure to supply dry, clean, oil free instrumentation grade compressed air may damage components of the analyzer as the cooled compressed air is blown in the analyzer.

8.2 Checking the filter

We recommend that you frequently check the air filter in order to protect the instrument from damage. Depending on your plant's air line supply, there may be more water and oil in the air than you think.

Never judge the effectiveness of a filter by its color. Very often filters can still look clean when they are not. The only way to be sure, is to dismantle the filter once a week or more and to feel the cartridge to see if it is oily or damp.

Clean the cartridge as recommended by the manufacturer, and replace it with a new one as soon as its condition appears doubtful.

8.2.1 Replacing the air filter

To replace the air filter:

1. Unscrew the filter cartridge collar counter clockwise.

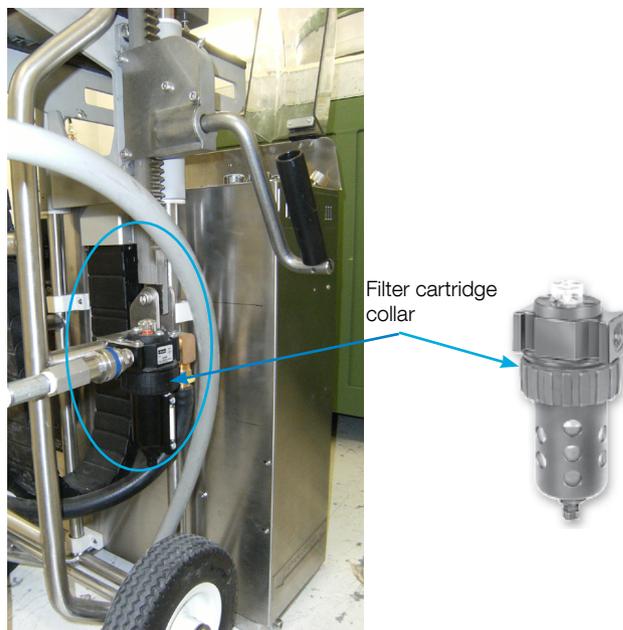


Figure 67: Air filter location

2. Remove the bottom plastic cover.
3. Unscrew the notched plastic disc at the bottom holding the filter in place.
4. Insert a new filter.
5. Screw the notched plastic disc in place.
6. Put the bottom plastic cover over the new filter
7. Screw the filter cartridge in place.

The air filter has a bottom screw that can be unscrewed to drain water.

A relieve valve is located on top of the air filter assembly to allow air to be relieved in case the filter is clogged to prevent damage to the filter assembly. When the filter becomes damaged or dirty, the indicator on the bottom part of the filter assembly becomes colored.

8.3 Compressed argon supply

The LiMCA III analyzer uses compressed argon to control the in-probe pressure and to pressurize the probe support seal. The argon pneumatic module uses an inert gas to prevent oxidation of liquid aluminum in the probe. This prevents

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the formation of solidified oxide bridges between the inner electrode and the probe that interfere with the in-probe melt level control process. The argon pneumatic module briefly consumes argon when pressurizing the probe support and switching to in-probe positive pressure. The module continuously consumes argon only while the probe is under vacuum.

- Provide clean compressed argon to the LiMCA III analyzer.
- Supply the analyzer with compressed argon 7/24 to ensure that it can hold a probe and control the in-probe pressure.
- Install external compressed argon filtering device for the argon supply. The LiMCA III analyzer has a 40 µm internal argon-filtering device.
- Ensure that compressed air supply to the analyzer respects the specifications contained in Table 11 2.

Establish a maintenance schedule of your compressed argon supply equipment to ensure that you respect the compressed argon supply specifications (see Table 11 2 on page 152).

Table 7: Argon supply specifications

Specifications	
Maximum temperature	40 °C (104 °F)
Minimum pressure	300 kPa, 45 PSI
Maximum pressure	800 kPa, 115 PSI
Minimum flow	0.015 m ³ /min, 0.5 SCFM
Filtration size	40 µm
Purity	99%
Dew point	-40 °C (-40 °F)
Hose internal diameter	4 mm (3/16 in)
Plant argon hose minimum internal	6 mm (1/4 in)



WARNING – Property damage

Failure to supply dry, clean, compressed argon may damage components of the pneumatic argon module.

8.3.1 Trouble shooting overheating problems

The following list contains aspects to check when a LiMCA III reaches warning or critical temperatures:

- Make sure sufficient compressed air pressure and flow is supplied to the system (refer to specifications in section “10.9 Analyzer compressed air supply specifications” on page 72). Look in log file for insufficient air pressure messages (when and how often).
 - Verify that compressed air is continuously fed to the system.
 - Increase input air pressure and flow from your supply system.
 - Enlarge inner diameter of compressed air feeding pipes and hoses.
 - Replace auto shutoff quick connects with fully open ones to reduce pressure drop.
- Make sure the supplied compressed air temperature is as low as possible.
- Make sure the heat shield is installed on the system.
- Install extra custom heat shields between the system and surrounding equipment generating significant radiation.
- If you cannot resolve the situation with the above checks, contact ABB service.

8.4 Embedded laser window

The LiMCA III uses a laser to measure the distance it is vertically positioned from the liquid metal surface. The laser window is hidden in a compartment at the left side of the LiMCA III head (see “Figure 68: Location of laser lens compartment” on page 65 below). The laser window compartment is continuously fed with a small compressed air leak to minimize risks of dust accumulation and to keep the window cool.



WARNING – Bodily injury

Never stare directly at the laser beam

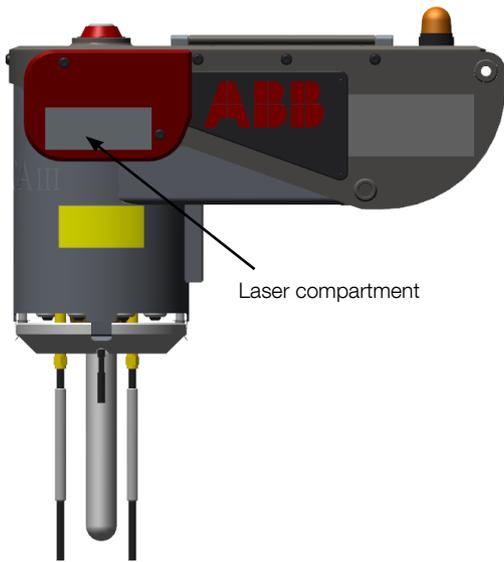


Figure 68: Location of laser lens compartment

Monthly verify that the window is clean to ensure that the laser can accurately measure the vertical distance of the analyzer to the liquid metal surface.

To clean the window:

1. Turn OFF the analyzer power to ensure that the laser beam is OFF.
2. Remove the heat shield (see “8.7.1 Removing the heat shield” on page 66).
3. Using a clean lens tissue or cloth, clean the laser lens and the compartment.
4. Reinstall the heat shield (see “8.7.2 Re-installing the heat shield” on page 66).
5. Power the analyzer back up.

8.5 Verifying operation of the maximum immersion detector

The maximum immersion detector (0004-19-0-00003-01) is a 6 mm (1/4 inch) steel rod installed at the bottom of the analyzer head. Its tip is located at the closest distance the analyzer can get to the melt surface without being damaged. Normally, the analyzer shall not reach a position this close to the melt. The maximum immersion detector is there to detect

such cases. The analyzer will automatically withdraw from the melt when the maximum immersion detector tip touches the melt.

It is recommended to periodically verify that the maximum immersion detector is operating, particularly after servicing components in the metal grounded enclosure.

To verify operation of the maximum immersion detector:

1. While the analyzer is powered ON and not measuring, using the manual controls panel buttons, bring the analyzer down, at least a few centimeters from its upper rest position.
2. Using an electrically conductive tool such as a screwdriver, make a contact between the maximum immersion detector and one of the electrodes.
3. The analyzer should immediately start to move up and the alarm indicator on the LiMCA III head shall be flashing.
4. In the web browser interface, in the log section, you can also verify that an error message ID 16016 was emitted relative to the detection of the maximum immersion detection.

8.6 Verifying operation of the in-probe maximum melt level detector

The in-probe melt level detector (ESD safe in-probe melt level detector) is a thermocouple assembly installed from the service trap on top of the LiMCA III head, through the mandrel, within the probe. The system detects that the probe is filled when the melt touches the tip of the in-probe melt level detector thermocouple.

The system also detects that the probe is excessively full of liquid metal when the melt touches the metal tube protecting the thermocouple. The system then immediately sets the in-probe pressure to atmosphere to prevent the melt from reaching the mandrel.

It is recommended to periodically verify the operation of the In-probe maximum melt level detector, particularly after servicing components in the metal grounded enclosure.

To perform this procedure, you need an 8 cm long, 2.54 cm O.D tube opened at both ends such as a truncated probe (probe with the closed end cut off). This tube is used to simulate that a probe is installed in the mandrel but still have

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access to the In-probe melt level detector. The truncated tube is not supplied with the LiMCA III system.

To verify operation of the in-probe maximum immersion detector:

1. While the analyzer is powered ON and not measuring, insert a truncated probe (8 cm long opened at both ends).
2. Using an electrically conductive tool such as a screwdriver, make a contact between the In-probe maximum immersion detector (tubing surrounding the thermocouple) and one of the electrodes. The analyzer sets the in-probe pressure to atmosphere and the alarm indicator shall be flashing.

From the console application, in the log section, you can also verify that an error message ID 16024 was emitted relative to detection of the in-probe maximum immersion detection.

8.7 Heat shield

The heat shield, as its name indicates, protects the analyzer from the heat radiation and convection, contributing to minimize the need to cool the analyzer. The heat shield also protects the analyzer from possible metal splashing.



WARNING – Bodily injury

Operating the analyzer above liquid metal without the heat shield may lead to overheating and possible failure of some analyzer components.

8.7.1 Removing the heat shield

To remove the heat shield:

1. Position the analyzer to a vertical position convenient to remove the heat shield.
2. Using small channel lock pliers, clean electrodes of excessive frozen metal.
3. On each side, pry off the heat shield from the clips (see [Figure 69](#) below).

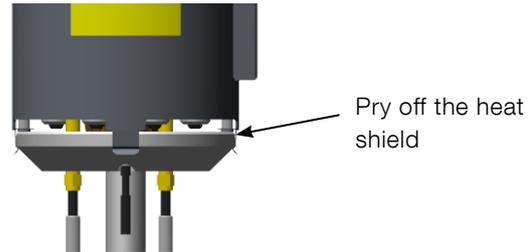


Figure 69: Heat shield

4. Carefully slide the heat shield down around the electrodes.

8.7.2 Re-installing the heat shield

To re-install the heat shield:

1. Using small channel lock pliers, remove frozen metal from the electrode to get a clean surface.
2. Position the heat shield below the analyzer aligning its holes with the electrodes and the maximum immersion detector, refer to "[Figure 12: The LiMCA III neck](#)" on [page 17](#).
3. Carefully bring vertically the heat shield up to the bottom of the analyzer head.
4. Slide vertically the heat shield and secure using the four clips.

8.8 Replacing the probe seal

The probe seal is a robust silicon rubber tube that surrounds and grabs the probe when it is pressurized in the analyzer mandrel.

The probe seal shall be changed if there are indications that there is a pressure leak around the probe or if its internal surface damaged.

To replace the probe support seal:

1. Bring the analyzer to a vertical position suitable for changing the probe support seal.
2. Turn OFF the analyzer.
3. Remove the heat shield (see "[8.7.1 Removing the heat shield](#)" on [page 66](#)).
4. Make sure that the electrodes are not hot (to prevent injuries) and are clean (to prevent scratching the inner

surface of the seal). If not, remove the electrodes before proceeding.

- Using a large flat screwdriver or a small adjustable wrench, loosen the large copper colored nut that hold the probe seal counterclockwise (not shown in the picture).

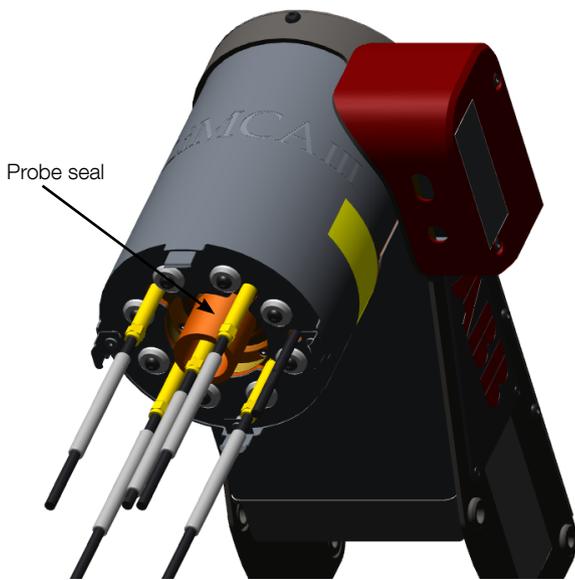


Figure 70: Probe support cartridge

- Remove the old probe seal and insert a new probe seal in the probe support cartridge, using the part describes below:

Part number	Description	Probe seal
LMA2902D	Probe seal	

- Rotate the copper coloured nut clockwise (looking up to the cartridge).
- Using a large flat screwdriver or a small adjustable wrench, tighten the copper coloured nut of the probe

support cartridge.

- Reinstall removed electrodes.
- Reinstall the heat shield (see "8.7.2 Re-installing the heat shield" on page 66).
- Turn the analyzer power ON and wait for it to boot.
- Insert a probe in the mandrel to make sure the system can grab it.
- Leave the probe installed for a few minutes and from the web browser interface application, verify that there are no argon leaks to the probe support. From the detailed status window (Analyzer menu), verify that the „Probe support pressure“ value is stable (not dropping).

8.9 List of consumables

Table 8 lists the various LiMCA III consumable parts.

Table 8: List of spare LiMCA III modules

Part number	Description
0050-19-0-00006-01	Melt Consumable Set
0050-19-0-00005-01	In-probe safety level assembly (lot of 2)
0004-19-0-00003-01	Maximum Immersion Detectors Set (Lot Of 2)
0050-19-0-00002-01	LiMCA III External electrodes Set (Lot Of 4)
0050-19-0-00003-01	LiMCA III In-probe Electrode Set (Lot Of 4)
0050-19-0-00004-01	In-Probe Melt Level Detectors Set (Lot Of 5)
LMA0500D	Aluminosilicate Sampling Tubes (Lot Of 24)
LMA0700D	Aluminosilicate Tubes With Ext. (Lot Of 24)
AA011856-01	LiMCA III mandrel heat deflector

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9 Software service

9.1 Finding the application release

To find the release number, start the application and select About from the Help menu. The application release number is shown in the About the LiMCA III Application screen (see Figure 71 below).



Figure 71: About the LiMCA III Application screen

9.2 Finding the versions of embedded firmware components

To find the version numbers of the firmware components click on "Version Information". The following information is displayed: SW Release ID, FW release ID, FPGA Release, and PLC Release ID.

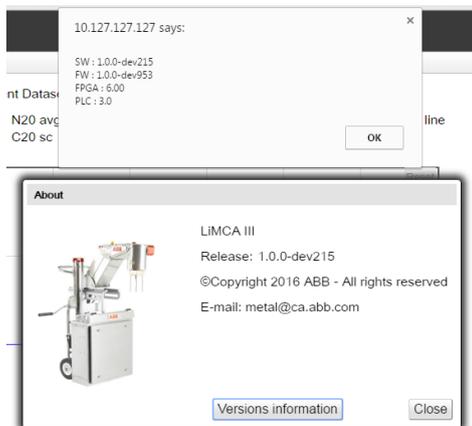


Figure 72: Firmware versions dialog box

9.3 IP address

Refer to "5.4 Network configuration" on page 36

9.3.1 Retrieving IP address

Refer to "5.4 Network configuration" on page 36

9.3.2 Changing IP address

Refer to "5.4.2 How to retrieve an IP address" on page 36.

9.4 Uploading a new software version

To upload a new software version into the LiMCA III system, proceed as follows:

1. Terminate all measurements (if applicable) and turn the LiMCA III instrument OFF.
2. Insert the USB key with the new software version into the USB connector.
3. Restart the LiMCA III instrument.
4. When the lights of the manual controls interface turn on solid white the software upload is completed.
5. Remove the key and restart the LiMCA III instrument.

10 Troubleshooting

10.1 Metal solidifying in probe

Symptoms	The metal freezes in the probe a bit above the external liquid metal level.
Possible cause	The tip of the in-probe melt level detector thermocouple is too high above the external liquid metal level. In-probe liquid metal freezes when it reaches the thermocouple tip as it loses too much heat.
Verification	N/A
Preventing solution	<p>Reduce the metal level tracking distance to increase the probe immersion so that the in-probe melt level detector thermocouple tip is at the external liquid metal level. This minimizes the in-probe liquid metal heat losses.</p> <p>To adjust the probe immersion:</p> <ol style="list-style-type: none">1. Estimate the vertical distance between the in-probe melt level detector thermocouple tip is and the external liquid metal level (in mm).2. From the web browser interface application:<ol style="list-style-type: none">a. From the Analyzer menu, open the Presets configuration window.b. In the <i>Presets</i> dialog box, select <i>Before measurement</i> under <i>Analyzer settings</i>.c. Under <i>Melt level tracking</i>, reduce the value of the "Target tracking position" parameter by the distance evaluated above.4. Click on the <i>Apply</i> button at the bottom of the window to make the change effective.5. Verify that the analyzer readjusted correctly the probe immersion in the melt.
Recovery solution	<p>With this cause, the in-probe metal is probable frozen around the in-probe electrode and the in-probe melt level detector thermocouple tip.</p> <p>To recover from metal frozen in the probe around the in-probe melt level detector thermocouple tip:</p> <ol style="list-style-type: none">1. Attempt to re-melt the in-probe metal by one of the following method:<ol style="list-style-type: none">a. If liquid metal is still available, immerse and maintain the probe deeper in the melt for several minutes.b. Use a torch. Be careful to not burn or overheat any analyzer component.c. When the metal unfreezes, remove the probe.2. If you cannot re-melt the in-probe metal:<ol style="list-style-type: none">a. Break the probe. Remove as much broken glass as possible. Be careful to not damage the surface of the probe seal with broken glass pieces stock in the mandrel.b. Cut the in-probe melt level detector thermocouple tip.3. Unscrew the in-probe electrode and the frozen metal on it. (You can attempt to recycle the electrode by melting the frozen metal on it.4. Install a new in-probe electrode and a new in-probe melt level detector (see Sections 4.7.2 on page 33 and 4.7.4 on page 34).
Symptoms	The liquid metal froze all the way up to the bottom of the stainless steel tube of the In-probe metal level detector.
Possible cause	The probe broke while under vacuum or went under vacuum after it broke. The liquid metal then immediately reached the to the bottom of the stainless steel tube of the In-probe metal level detector that acts as a shorting device to notify the system to immediately put the probe to atmospheric pressure, thus preventing liquid metal to move further up.
Verification	Verify the state of the probe to confirm that it is broken.

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Preventing solution

Make sure that the probe is properly preheated before it touches the liquid metal.

To configure the probe preheating:

5.
 - f. Under *Melt level tracking*, reduce the value of the “Target tracking position” parameter by the distance evaluated above.
 7. Click on the *Apply* button at the bottom of the window to make the change effective.
 8. Verify that the analyzer readjusted correctly the probe immersion in the melt.
-
1. From the web browser interface application::
 - a. From the Analyzer menu, open the Presets configuration window.
 - b. In the *Presets* dialog box, select *Before measurement* under *Analyzer settings*.
 - c. Under “Probe pre-heating”, make sure that the value of the “Pre-heating position” parameter is at least 120 mm. If waves of liquid metal are present, consider increasing the value further with the estimated peak wave amplitude.
 - d. Under “Probe pre-heating”, make sure that the value of the “Pre-heating temperature” parameter is set to at least 100°C. Consider increasing this value if the analyzer is exposed to cold ambient temperature or cool air drafts.
 - e. Under “Probe pre-heating”, make sure that the value of the “Pre-heating minimum time” parameter is set to at least 120 seconds. Consider increasing this value if the analyzer is exposed to cold ambient temperature or cool air drafts.
 2. Test this new configuration with the next probe immersion.

Recovery solution

With this cause, the in-probe metal is probable frozen around the in-probe electrode and the in-probe melt level detector thermocouple tip.

To recover from metal frozen in the probe around the in-probe melt level detector thermocouple tip:

1. Attempt to re-melt the in-probe metal by one of the following method:
 - a. If liquid metal is still available, immerse and maintain the probe deeper in the melt for several minutes.
 - b. Use a torch. Be careful to not burn or overheat any analyzer component.
 - c. When the metal unfreezes, remove the probe.
 2. If you cannot re-melt the in-probe metal:
 - a. Break the probe. Remove as much broken glass as possible. Be careful to not damage the surface of the probe seal with broken glass pieces stock in the mandrel.
 - b. Cut the in-probe melt level detector thermocouple tip.
 3. Unscrew the in-probe electrode and the frozen metal on it. (You can attempt to recycle the electrode by melting the frozen metal on it.
 4. Install a new in-probe electrode and a new in-probe melt level detector (see Sections [4.7.2 on page 33](#) and [4.7.4 on page 34](#)).
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10.2 Probe support seal inflated while no probe

Symptoms	The probe support seal is inflated blocking the way to insert a probe.
Possible cause	Unknown
Verification	N/A
Solution	On the LiMCA III head, press the probe release button. The probe seal pressure shall be immediately released.

10.3 Power indicator does not come on

Symptoms	When turning the analyzer power switch ON, the manual controls panel power indicator does not come ON.
Possible cause	AC cord not connected Analyzer breaker disengaged
Verification	<ol style="list-style-type: none">1. Verify that the AC power cord connections to the analyzers.2. Open the analyzer:<ol style="list-style-type: none">a. Verify that the AC power breakers, located on the left top part of the enclosure, on the relay module, are in the ON position.b. Verify that the AC power is properly configured (see “4.4.1 Electrical supply” on page 31. Verify that all internal connectors, particularly those associated with the relay and power supply modules are properly connected.
Solution	Connect AC power cord. Reset breakers Contact ABB Service department.

10.4 Manual controls panel OK, indicator does not flash properly

Symptoms	After tuning the analyzer power switch ON, the ready indicator does not start to flash or keeps flashing indefinitely
Possible cause	Instrument module problem or probe not in place
Verification	<ol style="list-style-type: none">1. Turn the analyzer power switch OFF, wait 15 seconds and turn the power switch back ON.2. If the problem is still there:<ol style="list-style-type: none">a. Turn the analyzer power OFF.
Solution	Contact ABB Service department with the log file information.

10.5 Alarm indicator turns ON

Symptoms	The analyzer alarm indicator turns ON or flashes.
Possible cause	Analyzer Emergency button engaged Insufficient compressed air or argon supply Numerous other conditions requiring the assistance of the operator
Verification	<ol style="list-style-type: none">1. Verify that the Emergency button is not in its pushed lock position. If it is the case, pull it and verify if the alarm indicator turns OFF.2. Verify that compressed air and argon supplies are connected and providing adequate pressure.3. Open a web browser interface application, connect to the analyzer and scan the log window for the most recent error events. Review each error event and attempt to correct the possible causes until the alarm indicator turns OFF.
Solution	Contact ABB Service department.

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Appendix A - Technical Specifications

10.6 Measurements

Particle size measurement	20-155 μm
Particle size detection	15-300 μm
Inclusion concentration (numerical)	0.05-1000 k/kg
Reproducibility at high inclusion concentration	$\pm 10\%$
Reproducibility at low inclusion concentration	Dominated by statistical noise
Typical melt sample mass	17.5 g
Typical melt sample volume	7.5 ml
Typical data sample interval	80.0 seconds

10.7 Ambient specifications

Operating ambient temperature	0-50 $^{\circ}\text{C}$ (32-122 $^{\circ}\text{F}$), with active cooling
Storage ambient temperature	-20 to +40 $^{\circ}\text{C}$ (-4 to 104 $^{\circ}\text{F}$)
Internal operating temperature	-5 to + 50 $^{\circ}\text{C}$ (23-122 $^{\circ}\text{F}$)
Ambient humidity	35-85 % RH non-condensing

10.8 Electric power supply specifications

Rated nominal line voltage	100-240 VAC autoselect
Line voltage phases	Single, neutral grounded VAC
Maximum line voltage fluctuation	10 %
Rated frequency	47-63 Hz
Rated power consumption	200 VA, average 450 VA, peak
Breaker type (100-240VAC)	5A, 2 poles, Tripping curve K (according to IEC/EN 60947-2)
Minimum extension wire gauge	18 AWG

10.9 Analyzer compressed air supply specifications

Maximum temperature	40 $^{\circ}\text{C}$ (104 $^{\circ}\text{F}$)
Minimum pressure	552 kPa (80 PSI)
Maximum input pressure	1400 kPa (200 PSI)
Flow at 552 kPa (80PSIG)	481 SLPM, typically 17 SCFM (max. 25 SCFM)
Filter	0.3 μm
Purity	99%
Dew point	-40 $^{\circ}\text{C}$ (-40 $^{\circ}\text{F}$)
LiMCA air hose internal diameter	19.05 mm (0.75 in)
Plant argon hose minimum internal diameter	12.7 mm (0.5 in)

DANGER – Serious damage to health / risk to life



Failure to supply dry compressed air to the LiMCA III system may result in water dripping from the analyzer. Water dripping on process components to be in contact with liquid metal can cause an explosion.

DANGER – Serious damage to health / risk to life



Failure to supply dry, clean, oil free instrumentation grade compressed air may damage components of the analyzer as the cooled compressed air is blown in the analyzer.

10.10 Analyzer compressed argon supply specifications

Maximum temperature	40 °C (104 °F)
Minimum pressure	300 kPa (45 PSI)
Maximum input pressure	800 kPa (115 PSI)
Minimum flow	0.015 m ³ /min, 0.5 SCFM
Filter size	40 µm
Purity	99%
Dew point	-40 °C (-40 °F)
LIMCA argon hose internal diameter	4mm (3/16 in)
Plant argon hose minimum internal diameter	6 mm (1/4 in)



DANGER – Serious damage to health / risk to life

Failure to supply dry, clean, compressed argon may damage components of the pneumatic argon module.

10.11 Laser specifications

Laser classification	Class 2 (IEC) / Class II (FDA)
Laser power	Less than 1 mW
Laser light source wavelength	655 nm
Laser light source	visible red light
Laser measuring range	200-1000 mm (7.9 - 39 in)
Laser measuring resolution	0.3 mm

10.12 Analyzer mechanical specifications

Mass	80 kg (176 lbs)
Height	1260 mm (50 in)
Width	510 mm (20 in)
Depth	470 mm (19 in)
Transit case mass	65 kg (143 lbs)

Documentation for LIMCA III instrument is available for download from www.abb.com

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Appendix B - List of system events.

ID	Level	Message	Cause	Resolution
10010	1	Metal module initialized	The Metal module has been initialized (but not started yet)	
10011	1	Metal module started	Normal thread start at boot time.	
10013	1	Metal detected at T/C with slope (%f superior to %d)	The slope method detected the that the metal has reached the T/C	
10014	1	Metal detected at T/C with temperature (%f superior to %f)	The max. temperature method detected the that the metal has reached the T/C	
10015	1	U/D ratio point: %s volume = %f	A U2D or D2U point has been reached	
10017	1	Actuator module started	Normal thread start at boot time.	
10025	1	Pneumatic module started	Normal thread start at boot time.	
10027	1	Zero energy mode command received	The pneumatic module received a zero energy command.	
10028	1	Grab probe command received		
10029	1	Release probe command received		
10031	1	Pressure command received		
10032	1	Vacuum command received		
10033	1	Atmosphere (normal) command received		
10034	1	Atmosphere (quick) command received		
10035	1	Cannot set vacuum/pressure/atmosphere in probe: already in requested mode	The pneumatic module received a vac/pres/atm command but the desired mode is already set	
10036	1	ESZ module initialized	The ESZ module has been initialized (but not started yet)	
10037	1	ESZ module started	Normal thread start at boot time.	
10039	1	Conditioning sequence started		
10040	1	EC turned ON		
10041	1	EC turned OFF		
10042	1	EC status: %s value = %f		
10043	1	High power transformer turned ON		
10044	1	High power transformer turned OFF		
10047	1	Acquisition/scope module initialized	The Acquisition/scope module has been initialized (but not started yet)	
10048	1	Acquisition/scope module started	Normal thread start at boot time.	
10049	1	Acquisition/scope module stopped		
10051	1	New scope parameters received		
10056	1	New calibration parameters: factor = %f (old was %f), current = %f (old was %f)		
10069	1	Acquisition stopped		
10070	1	Acquisition aborted		
10071	1	Command and Control module initialized	The Command and Control module has been initialized (but not started yet)	

10072	1	Command and Control module started	Normal thread start at boot time.
10077	1	Cooling module initialized	Cooling module initialized
10078	1	Cooling module started	Cooling module started
10080	1	Health manager module initialized	The Health manager module has been initialized (but not started yet)
10081	1	Health manager module started	Normal thread start at boot time.
10082	1	Health manager module stopped	
10083	1	Metal reached T/C, turning down	
10084	1	Down cycle time reached, turning up	
10085	1	Aborting manual cycling	
10087	1	Cannot start a Measuring sequence while a withdrawal or quick-out sequence is active.	
10088	1	Cannot start an emergency out sequence because it is already active.	
10089	1	Withdrawal sequence: Sending command to remove probe	
10095	1	LiMCA II Pulse detection algorithm is being used.	First hump only.
10096	1	LiMCA III Pulse detection algorithm is being used.	Highest hump.
10097	1	Pneumatic argon zero-energy reached.	
10098	1	Zero energy mode command received	The cooling module received a zero energy command.
10099	1	Input air zero-energy reached.	
10100	1	Start zero-energy command received	
10102	1	Exit or abort zero-energy mode command received	
10103	1	Zero-energy sequence started.	
10104	1	Continuing with argon and input air zero-energy (command received)	
10105	1	Resume command received - resuming at ESZ module	
10106	1	Resume command received - resuming at argon	
10107	1	Resume command received - resuming at input air	
10109	1	Stop zero-energy command received	
10110	1	Resume command received - resuming at argon and input air preparation	
10111	1	Signal module started	Normal thread start at boot time.
12033	1	New sample written to file %s	
12020	2	Analyzer re-coupled with actuator	
12027	2	Normal acquisition started	
12028	2	SPV acquisition started	
12029	2	External calibration acquisition started	

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12046	2	Probe detected	
12047	2	Release button pressed	
12048	2	Emergency button pressed	
12049	2	Emergency button released	
12050	2	Start command from Front Panel	
12051	2	Stop command from Front Panel	
12060	2	Orifice unblocking sequence conditioning for U/D ratio = %d %	
12061	2	Acquisition stopped -- Metal has reached thermocouple	
12063	2	Head temperature (%f °C) now below warning level (%f °C)	The head temperature was above the warning level but is now back to an acceptable level.
12064	2	Mandrel temperature (%f °C) now below warning level (%f °C)	The mandrel temperature was above the warning level but is now back to an acceptable level.
12065	2	Body temperature (%f °C) now below warning level (%f °C)	The body temperature was above the warning level but is now back to an acceptable level.
12070	2	Head temperature (%f °C) now below critical level (%f °C)	The head temperature was above the critical level but is now back to an acceptable level.
12071	2	Mandrel temperature (%f °C) now below critical level (%f °C)	The mandrel temperature was above the critical level but is now back to an acceptable level.
12072	2	Body temperature (%f °C) now below critical level (%f °C)	The laser temperature was above the critical level but is now back to an acceptable level.
12084	2	Starting Preparing For Measurement sequence	
12085	2	Starting Measuring sequence with the orifice already immersed	
12086	2	Aborting Measuring sequence	
12087	2	No electrical contact during immersion - Executing P/V cycle # %d	
12088	2	Automatic conditioning during immersion at %f ml (T/C at %f ml)	
12089	2	Immersion sequence done -- Starting measuring	
12091	2	Aborting Measuring sequence before removing probe	
12095	2	Argon input pressure back to acceptable level.	
12096	2	Regulated argon pressure back to acceptable level.	

12098	2	Withdrawal sequence: boost after %d seconds		
12099	2	High-power ultra-capacitors discharged (after %d seconds)		
12112	2	Pre-heating temperature (%d C) is not yet reached (current = %d C), lowering analyzer to %d mm		
14001	3	Zero-energy mode not allowed, sequence already active.	The zero-energy procedure cannot be started while a sequence is active.	Terminate any active sequence before starting a zero-energy procedure.
14002	3	Zero energy mode already activated	The pneumatic module received a command to go to the zero-energy mode but it is already activated.	
14003	3	Cannot grab probe: probe not detected	The pneumatic module received a command to grab a probe but no probe is detected.	Make sure a probe is firmly inserted in the mandrel.
14004	3	Cannot release probe: no probe grabbed	Pressing the Release Probe button on the analyzer control panel while no probe is grabbed by the mandrel.	
14005	3	Cannot set pressure in probe: no probe	The pneumatic module received a pressure command but no probe is grabbed.	
14006	3	Cannot set vacuum in probe: no probe	The pneumatic module received a vacuum command but no probe is grabbed.	
14007	3	Probe support pressure (%f KPa) needs to be refreshed (inferior to %f KPa)	The pressure in the probe support dropped to a level where it needs to be refreshed. May be cause by a leak.	Make sure the tubing between the pneumatic and the mandrel modules is not pinched when the analyzer door is closed. I247 Verify the state of the tubing. Replace any damaged tubing.
14008	3	Zero energy mode not allowed while a sequence is active	The zero-energy procedure cannot be started while a sequence is active.	Terminate any active sequence before starting a zero-energy procedure.
14009	3	Manual control of in-probe pressure is not allowed	Manual control not allowed while a sequence is active.	Terminate any active sequence before activating a manual control.
14010	3	Manual control of ESZ electrodes current is not allowed	Manual control not allowed while a sequence is active.	Terminate any active sequence before activating a manual control.
14011	3	Manual control of metal cycling is not allowed	Manual control not allowed while a sequence is active.	Terminate any active sequence before activating a manual control.
14012	3	Manual control acquisition is not allowed	Manual control not allowed while a sequence is active.	Terminate any active sequence before activating a manual control.
14013	3	Cannot start a SPV acquisition while a sequence is active	SPV acquisition not allowed while a sequence is active.	Terminate any active sequence before activating an SPV acquisition.
14015	3	Cannot start acquisition, electrode current too low	Not enough current between electrode to start an acquisition either because the UC are too low, or because there is no electrical contact between electrodes	Make sure that all three electrodes (1 negative inside and 2 positive outside the probe) are installed on the mandrel. Verify that they are well tighten.

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14016	3	Probe may be empty, setting it to VACUUM	In the metal cycling, while emptying the probe (down cycle), the electrical contact between electrodes was lost (not enough current) so the vacuum mode is set.	Verify the vertical position of the In-probe Melt Level Detector is slightly above the external melt surface. Monitor the melt cycling to see any misbehavior. I253If metal has solidified in the probe, replace the probe after removing frozen metal.
14017	3	Cannot grab probe -- Emergency Stop button active	Cannot activate grabbing of a probe while the Emergency Stop button is active (pushed in).	Release (pull) the Emergency Stop button on the analyzer control panel before inserting a probe in the mandrel. .
14019	3	Head temperature (%f °C) above warning level (%f °C)	The head temperature has reached the warning temperature.	Increase the cooling compressed air pressure. Optimize the cooling system configuration.
14020	3	Mandrel temperature (%f °C) above warning level (%f °C)	The mandrel temperature has reached the warning temperature.	Increase the cooling compressed air pressure. Optimize the cooling system configuration.
14021	3	Body temperature (%f °C) above warning level (%f °C)	The body temperature has reached the warning temperature.	Increase the cooling compressed air pressure. Optimize the cooling system configuration.
14027	3	Starting a Measuring sequence with a used probe	The system reports a probe as being used after it is installed on the mandrel and the Melt Distance value indicates the probe touched liquid metal for the first time. Accidentally cutting the laser beam for a few seconds above the tip of the installed probe causes a wrong interpretation that the probe was immersed.	Make sure the probe is in a good state before starting a measurement. I264Verify that nothing cuts or has cut the laser beam.
14028	3	Aborting a Measuring sequence for emergency withdrawal	Emergency withdrawal was activated.	
14029	3	Aborting a Withdrawal sequence for emergency withdrawal	Emergency withdrawal was activated.	
14030	3	Starting Emergency Withdrawal sequence	Emergency withdrawal was activated.	
14031	3	Cannot grab probe -- insufficient argon pressure	Insufficient argon pressure.	Verify that the input argon pressure to the system is sufficient. Make sure that the tubing between the pneumatic and mandrel modules are not pinched by the analyzer door and are in good condition.
14032	3	Cannot set pressure in probe -- insufficient argon pressure	Insufficient argon pressure.	Verify that the input argon pressure to the system is sufficient. Make sure that the tubing between the pneumatic and mandrel modules are not pinched by the analyzer door and are in good condition.

14033	3	Cannot set vacuum in probe -- insufficient argon pressure	Insufficient argon pressure.	Verify that the input argon pressure to the system is sufficient. Make sure that the tubing between the pneumatic and mandrel modules are not pinched by the analyzer door and are in good condition.
14034	3	Withdrawal sequence: Unable to remove probe	Although several command to remove the probe were issued during the Withdrawal sequence, the system still indicates that a probe is present. This does not stop the sequence to continue.	Try to remove the probe manually. Verify the state of the probe seal inner surface. Replace it if damaged.
14035	3	Emergency out sequence: Unable to remove probe	A command to remove the probe was issued but the system indicates that there is still a probe present. This does not stop the sequence to continue.	Try to remove the probe manually. Verify the state of the probe seal inner surface. Replace it if damaged.
14036	3	Cannot start a Measuring sequence, already active.	A start command have been received but a Measuring sequence is already active.	Terminate any active sequence before starting a Measuring sequence.
14038	3	Probe appears immediately full at beginning of cycle (up cycle duration is %d milliseconds)	Melt is detected at Metal T/C immediately after starting the probe filling part of the cycling.	Verify that the probe is not broken. Verify that the In-probe Melt Level Detector cools down while metal is flushed from the probe. Make sure that the Metal T/C tip is slightly above external melt surface and not touching the probe nor the electrode. Replace the In-probe Melt Level Detector if it does not appear to operate normally.
14039	3	Zero energy mode not allowed while a probe is installed		Remove the probe before starting a zero-energy procedure.
14047	3	Time-out occurred on terminating the Withdrawal sequence.	The system did not detect that it has reached the rest position within a 60 seconds time-out period. The actuator motor may be damaged.	Verify that the actuator is actually moving up. From the Status window of the Console application, check that the motor current value changes while the actuator is supposed to move up.
14048	3	Time-out occurred on terminating the quick-out sequence.	The system did not detect that it has reached the rest position within a 60 seconds time-out period.	Verify that the actuator is actually moving up. From the Status window of the Console application, check that the motor current value changes while the actuator is supposed to move up.
14049	3	Analyzer moved manually: aborting sequence	The analyzer was moved manually while a sequence is currently active. The current sequence is aborted.	Avoid manually lifting the analyzer while a sequence is active.

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12019	3	Actuator de-coupled from actuator	Analyzer raised manually. Analyzer component hanging and preventing decreasing vertical movement. Friction on the actuator vertical mechanism.	Verify that nothing around the system can prevent it from moving down. Manually move the analyzer up and down. If you sense unusual friction in the mechanism, contact ABB service.
16004	4	Cannot reach pneumatic zero energy because argon input pressure too high (unregulated %f KPa or regulated %f superior to %f KPa)	The zero energy for the pneumatic module cannot be reached because the argon input pressure does not go down after a specified time.	Make sure that the input argon source is disconnected from the analyzer.
16005	4	Probe support pressure (%f KPa) does not reach minimum pressure (%f KPa) to grab probe	The probe support pressure does not reach the minimum value required to consider the probe grabbed.	Verify that the argon input pressure supplied is sufficient. Verify that the tubing between the pneumatic and the mandrel module is not pinched by the analyzer door.
16006	4	Probe support pressure (%f KPa) remains higher than minimum (%f KPa) to release probe	The probe support pressure remains too high to consider the probe released.	Verify the state of the probe seal and of the tubing between the pneumatic and the mandrel module.
16007	4	Proportional valve output (%f KPa) takes too long to get in an acceptable range for pressure (inferior to %f KPa)	When switching from vacuum to pressure, the output of the proportional valve must be in an acceptable range because the output of the cut-off valve will be opened. If it takes too long, this message is issued.	Replace the pneumatic module.
16008	4	Cannot activate conditioning because no electrical contact between electrodes, or High-power Ultra-Capacitor exhausted	The conditioning sequence could not be carried on because the system cannot measure an electrical current between the electrodes.	Make sure that the probe is not empty. I363Make sure the three electrodes are installed and well tighten on the mandrel.
16009	4	Conditioning sequence aborted because ACQ module does not setup the conditioning mode	The acquisition module must configure the preamplifier input for a conditioning mode. This error indicates that it has not responded to a request.	Check log for indications.
16013	4	Start acquisition command received but the acquisition is already active	Possibly, start of a SPV acquisition while an acquisition was already active.	
16014	4	Cannot start a Measuring sequence while a withdrawal or quick-out sequence is active.		Terminate the active sequence before attempting to start another one.
16015	4	Orifice cannot be unblocked	The maximum # of conditioning based on the U/D ratio has been done and the orifice still seems blocked.	Restart the sequence and watch if orifice can be unblocked. Replace the probe. Skim melt surface before probe immersion.
16016	4	Maximum immersion level reached -- Raising analyzer	Laser distance measuring device may not be functioning properly.	Check that the laser optical ports are clean.
16018	4	Head temperature (%f °C) is critical (above %f °C) -- Raising analyzer	The head temperature is critically high.	Increase the cooling compressed air pressure. Optimize the cooling system configuration.

16019	4	Mandrel temperature (%f °C) is critical (above %f °C) -- Raising analyzer	The mandrel temperature is critically high.	Increase the cooling compressed air pressure. Optimize the cooling system configuration.
16020	4	Body temperature (%f °C) is critical (above %f °C) -- Raising analyzer	The Body temperature is critically high.	Increase the cooling compressed air pressure. Optimize the cooling system configuration.
16024	4	In-probe maximum melt level detected - Terminating	Broken probe. Defective thermocouple in In-probe Melt Level Detector.	Check if probe is broken. Replace In-probe Melt Level Detector.
16025	4	Cannot start a Measuring sequence because no probe installed.		Install a probe on the mandrel before attempting to start a Measuring sequence.
16026	4	Pre-heating position cannot be reached -- Aborting sequence	Analyzer not at measuring position above melt. Actuator motor not working.	Verify that the analyzer is at its measuring position above the melt. Verify that the actuator is actually moving down when the status indicates it does.
16027	4	Pre-heating temperature (%d C) cannot be reached (current = %d C) -- Aborting sequence	No liquid metal below probe. Defective In-Probe Melt Level Detector thermocouple. Very cool environment.	Replace the In-probe Melt level Detector. If the ambient temperature is low, try protecting the probe from cool drafts. Try reducing the pre-heating temperature configuration.
16028	4	No current during immersion after 8 P/V cycles -- Aborting sequence	Orifice could not be unblocked.	Restart the sequence. Gently hit on the probe while it is under vacuum to help unblock it. If no success, replace the probe. Skim the melt surface below the probe before immersion.
16029	4	Cannot fill probe during immersion -- Aborting sequence	Orifice could not be unblocked.	Restart the sequence. Gently hit on the probe while it is under vacuum to help unblock it. If no success, replace the probe. Skim the melt surface below the probe before immersion.
16030	4	Cannot start a Measuring sequence because no probe installed.	Probe must be installed on the mandrel to allow start of the Measuring sequence.	Install a probe on the mandrel before attempting to start a Measuring sequence.
16032	4	Aborting immersion sequence because broken probe detected	Diagnostic based on detection of a quick in-probe pressure drop.	Confirm that the probe is broken. Replace the probe. Verify the pre-heating configuration and execution to prevent other probe breakage.
16033	4	Insufficient argon input pressure (%f KPa lower than minimum of %f KPa)	Not enough argon pressure at the input. Can also be cause by a defective sensor.	Check that the argon supply is sufficient. Verify that the system reports the proper input pressure value. If not replace the Argon Pneumatic module. I500Check the argon cable tray hose and quick connects for leaks. Check the tubing in the analyzer for leaks.

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16034	4	Insufficient regulated argon pressure (%f KPa lower than minimum of %f KPa)	Not enough argon pressure at the output of the regulator. Can be cause by an insufficient input argon pressure, a bad adjustment of the regulator, a defective regulator or a defective pressure sensor.	Re-adjust the regulator for an acceptable pressure, replace the regulator, replace the sensor.
16035	4	Input pressure is fine while the regulated output is too low.	This may indicate that the regulator is not correctly adjusted, that it is defective or that the input argon pressure sensor is defective.	Re-adjust the regulator for an acceptable pressure, replace the regulator, replace the sensor. Verify that the system reports the proper input pressure value. If not replace the Argon Pneumatic module.
16036	4	Regulated argon pressure is fine while input pressure too low.	This may indicate that either one of the pressure sensor are defective.	Verify that the system reports proper pressure values. If not replace the Argon Pneumatic module.
16037	4	Pressure not stable		
16038	3	Takes too long to reach in-probe pressure target.		Verify that the input Argon pressure is adequate. Verify that the tubing between the pneumatic and the mandrel modules is not pinched by the analyzer door and is in good condition.
16039	4	Time-out emptying probe in Withdrawal sequence -- WARNING: probe may still contain liquid metal	It takes too long to loose the electrical contact between electrode, so the sequence goes on even if the probe may not be entirely empty. Probe orifice is blocked.	
16041	4	Cannot grab probe, zero energy sequence active	The system does not allow grabbing a probe while the zero-energy sequence is active.	Terminate the zero-energy procedure before attempting to install a probe on the mandrel.
16042	4	Cannot reach zero energy because air input pressure is too high (%f KPa superior to %f KPa)	The zero energy for the cooling module cannot be reached because the air input pressure does not go down after a specified time.	Make sure to disconnect the input compressed air supply to the analyzer.
16043	4	Cannot discharged high-power ultra-capacitors, no electrical contact between electrodes (EC = %f A HUC voltage = %f V)	No electrical contact detected between the electrodes.	Make sure the shorting plate is properly installed and electrodes are clean to insure a good electrical contact. If not, clean the electrodes before installing the shorting plate.
16045	4	Takes too long to discharge high-power ultra-capacitor (EC = %f A HUC voltage = %f V) -- Aborting.	Time out on high-power ultra-capacitor discharge.	Make sure the shorting plate is properly installed and electrodes are clean to insure a good electrical contact. If not, clean the electrodes before installing the shorting plate.
16046	4	Cannot go to zero energy mode because a probe is installed	The pneumatic module received a command to go to the zero-energy mode but a probe is installed.	Remove the probe before starting a zero-energy procedure.

16047	4	Zero-energy mode already active		Terminate the active sequence before attempting to start another one.
16048	4	Withdrawal sequence not allowed while zero-energy mode is active		Terminate the active sequence before attempting to start another one.
16049	4	Quick-out sequence not allowed while zero-energy mode is active		Terminate the active sequence before attempting to start another one.
16050	4	Manual metal cycling control not allowed while another sequence is active		Terminate the active sequence before attempting to start another one.
16051	4	External calibration sequence not allowed while another sequence is active		Terminate the active sequence before attempting to start another one.
16052	4	Zero-energy mode not allowed while a probe is installed		Remove the probe before starting a zero-energy procedure.
16053	4	Zero-energy mode not allowed while a Withdrawal sequence is active		Terminate the active sequence before attempting to start another one.
16054	4	Zero-energy mode not allowed while a Measuring sequence is active		Terminate the active sequence before attempting to start another one.
16055	4	Zero-energy mode not allowed while metal cycling sequence is active		Terminate the active sequence before attempting to start another one.
16056	4	Probe appears immediately full at beginning of cycle %d times in a row -- aborting sequence	Melt is detected at Metal T/C immediately after starting the probe filling part of the cycling a number of consecutive times in a row. The Measuring sequence is aborted.	Verify that the In-probe Melt Level Detector T/C cools down while metal is flushed from the probe. Make sure that the In-probe Melt Level Detector tip is slightly above external melt surface and not touching the probe nor the electrode. Verify that the metal is not frozen in the probe. Replace the probe.
16058	4	The acquisition cannot be started because the ESZ module will not go to acquisition mode.	Low power ultra-capacitors exhausted.	Allow time to recharge Low power ultra-capacitors.
16059	4	The DSP does not start acquisition.	Hardware problem. The firmware should automatically re-initialize the DSP.	
16060	4	The DSP takes too long to complete acquisition.	Hardware problem. The firmware should automatically re-initialize the DSP.	
16062	4	Time-out trying to re-couple analyzer with actuator.	Actuator motor or upper limit switch failure.	Verify that the actuator is actually moving up when system status reports so. From the Status window of the Console application, check that the motor current value changes while the actuator is supposed to move up. If the analyzer is actually at its upper rest position and you have this message, the upper limit switch is probably defective. Contact ABB service.
16065	4	Error writing sample data to permanent storage -- sample lost	Flash problem or brain module failure.	Replace brain module. Contact ABB service.
16066	4	Error opening odometer file -- odometers reset.	Flash problem or brain module failure.	Replace brain module. Contact ABB service.

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16068	4	Cannot maintain appropriate probe support pressure.	Leak in the probe support mechanism, or in the pneumatic module.	Verify probe support mechanism. Replace Mandrel module or Argon Pneumatic module if needed.
16069	4	Cannot remove probe -- Still detected in support	It takes too long to remove the probe as it is still detected in the support.	Verify the state of the probe seal. Replace if damaged.
16076	4	Cannot reach target in-probe pressure after 5 attempts.	Most probably linked to obstructed tubing between the Pneumatic Module and the Mandrel module.	Verify tube between the Pneumatic Module and the Mandrel module to ensure it is connected and not bent sharply or not pinched when the Analyzer main enclosure door is closed.
16077	4	Five consecutive invalid samples with extremely low acquisition time (below 1%) with DSP error 3 occurrences.	Five consecutive samples with error 3 from the DSP during the acquisition combined with extremely low (below 1% of the target) sample acquisition time. One probable cause is that a ground is missing between the metal-grounded enclosure and the external electrode.	Make sure that the metal-grounded enclosure is properly grounded to the external electrode.
16078	4	Analyzer appears not leaving the upper rest position. Check state of motor and upper rest position limit switch.	After 2 seconds of down movement, the upper rest switch is still active.	Check if motor is working, or if the upper limit switch is working.
16079	4	Analyzer de-coupled from actuator: aborting sequence	The analyzer was de-coupled from the actuator while a sequence was active. The sequence is aborted.	If the analyzer was not de-coupled manually, check if something may have restricted the analyzer from moving down.
16089	4	PLC module stated		
16090	4	PLC module stopped		
18001	5	Current source is in over current state -- FATAL: Restart analyzer	Current Source module hardware problem.	Restart the analyzer. If problem still there, replace the Current Source module. Contact ABB service.
18004	5	Warning closing configuration file		
16091	4	Cannot start an acquisition while a conditioning is active -- delayed		
16092	4	Release probe pressed even when no probe - releasing pressure anyway		
16093	4	Cannot start conditioning -- not enough input air pressure for cooling		
16094	4	Cannot start conditioning -- zero-energy mode activated.		
16095	4	module : %s has crash and has been restarted		
16096	4	module : %s has crash too many times, stop refreshing watchdog		
16097	4	module : %s seems to be running smoothly, removing it from blacklist		
16098	4	Probe already installed		
16099	4	Watchdog not refreshed for %d seconds...		

16100	4	Too many conditioning -- aborting sequence		
16101	4	Do not appear to leave rest position -- aborting sequence		
14050	3	Invalid command while in monitoring state: %s		
10202	1	CCM command queue: Received command %s		
10203	1	ATM button pressed / command sent		
10204	1	VAC button pressed / command sent		
10205	1	COND button pressed / command sent		
10206	1	Body cooling activated		
10207	1	Body cooling completed		
10208	1	Head cooling activated		
10209	1	Head cooling completed		
10210	1	unable to access/update odometers files		
10211	1	log history is corrupted, discarding current file and creating a new one		
10212	1	Preparation for zero-energy received by the pneumatic module		
10213	1	Exiting zero-energy mode in the pneumatic module		
16102	4	PLC or FESTO not connected		
10214	1	%s module (id #%d) registered with watchdog manager		
10215	1	%s module (id #%d) un-registered with watchdog manager		
16103	4	matlab not found - data processing disabled		
10216	1	L3SignalCreateComputeRangeSQE: Maximum computeRangeSQE buffer size reached		
10217	1	L3SignalCreateValidRangeSQE: Maximum validRangeSQE buffer size reached		
10218	1	L3SignalSearchL2Pulses: Maximum wrkThresPosSQE buffer size reached		
10219	1	L3SignalSearchL3Pulses: Maximum wrkThresPosSQE buffer size reached		
14051	3	now used probe (meltdist = %d < in metal config = %d)		
16104	4	Request to power ESZ electronics with LUC		
10220	1	HMM alarm queue: Received alarm %s state = %s		
10221	3	Oldest logs have been discard, max length reach		
16105	4	Invalid ESZ module input command (%s)		
16106	4	Unknown cycling mode (%s)		
14052	3	Zero-energy continue command received out of sequence (state = %s)		

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14053	3	Zero-energy resume command received out of sequence (state = %s)		
16107	4	L3SignalSetAcq: Invalid acquisition parameter (hl(%d)<0 or th(%f)<0)		
16108	4	L3SignalSetScope: Invalid scope parameter (fl(%d)>%d or #pts(%d)>%d)		
16109	4	L3SignalSetScope: Invalid scope parameter (-2.5>t(%f)>2.5 or 0>tp(%d)>2.5)		
16110	4	Cannot start a SPV while there is electrical contact between electrodes.	If there is an electrical contact between the electrodes, the SPV results will not be correct so it is not allowed.	Remove the electrical contact between electrodes.
16111	4	SPV Acquisition sequence not allowed while another sequence is active		Terminate the active sequence before attempting to start another one.
16112	4	Cannot start SPV Acquisition: shunt resistor not connected	Try to connect the shunt but cannot get a proper current reading	Possibly a hardware problem, contact ABB service
16113	4	Cannot start External Calibration: no electrical contact between electrodes	Probably that the external calibrator has not been properly installed.	Correctly install the external calibrator before starting an external calibration

Notes

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Notes

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