ROMANOFF®
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Technical Documentation

Mini Casting unit MC16

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Keep for future use!

Revision

Date	chapter	Reason	responsible
2017-07-24	All	Edition 2017	RK
2018-01-29	All	Edition 2018	RK
2019-10-16	All	last changes	RK

This manual has been prepared in good faith by us. Nevertheless, should you find any mistakes or ambiguities, please let us know. Furthermore, we are grateful for comments and suggestions

Contents

1 General information

1.1 Scope of delivery and responsibilities

The vacuum pressure casting machine MC16 is delivered complete. Please check delivery immediately after receiving the shipment if there is something missing or possible transport damages. Please tell the faults the shipping agency and your dealer.

1.2 Liability, warranty and guarantee

The company *INDUTHERM Erwärmungsanlagen GmbH* take liability, warranty and guarantee according to the legal regulations.

The vacuum pressure casting machine is built to be state-of-the-art and in compliance with the accepted safety regulations. Nevertheless, can improper installation and non-intended using lead to danger and damages.

INDUTHERM Erwärmungsanlagen GmbH don't take liability for damage caused by untrained personnel operating the machine.

For damages because of demonstrably misusing of machine or because of abnormal behaviour no liability will be taken by *INDUTHERM Erwärmungsanlagen GmbH!*

INDUTHERM Erwärmungsanlagen GmbH don't take liability for damages caused by faulty protection of power supply and/or wrong connecting the supplies (protective gas, water, compressed air).

There is no guarantee for consumables by *INDUTHERM Erwärmungsanlagen GmbH*.

Company *INDUTHERM Erwärmungsanlagen GmbH* can not and will not take responsibility for all consequential damages caused by above mentioned circumstances.

This operating manual is of the technical state at printing date. All rights reserved regarding technical changings and different equipment.

Damages caused by disregard, wrong interpretation and non-compliance with specifications in this manual will lead to expiration of guarantee for this system.

1.3 Responsibility of operating company

The operator has to meet with national accident preventing regulations and technical regulations.

Operating company is allowed to let operate machine by trained and trustworthy personnel only.

Operating company has to make sure the system is supervised by personnel which is trained at this device.

Operating manual must be kept right next to the system.

Operating company has to ensure operating personnel has **read and understood** the manual before they are going to use the machine.

Operating company has to ensure unauthorized person has no access to the system.

Maintenance actions may only be done by authorized personnel or by service technicians from manufacturer.

1.4 EC-conformity

Declaration of European Community conformity is attached to this manual.

1.5 Observation of the product

The management will provide you with a secure machine at state-of-the-art.
Please let us know immediately if there are:

- failures at safety measurement devices,
- failures during production,
- modified parameter settings,
- difficulties in using the system,
- accidents or near accidents and
- remarks for improvement of the manual.

2 Safety

2.1 Intended use

Operational safety of the mini casting machine is only guaranteed at intended use.

The mini casting machine serves exclusively for melting, pouring and vacuum casting of commercially available precious metals and of copper- or aluminium-alloys. Dental alloys and high reactive alloy like magnesium can't be melted. The specified temperature ranges must be complied with.

Every other use of the overall plant or parts is considered as not intended.

Unauthorized modifications of the plant are prohibited because of reasons for safety! The declaration of conformity will expire with modification.

Intended use includes reading, knowing and obeying the operating instructions. That also contains observing of servicing and maintenance regulations.

Set up, operation and maintenance is only allowed to be carried out by trained qualified personal that has read and understood all documents.

The plant may affiliate only to the specified media. Supply voltage and input respectively output pressure have to be observed to the given device labelling accordingly.

The machine has been developed for use in enclosed spaces and for the above-mentioned application.

Only original INDUTHERM consumables and spare parts are admitted for operation.

It is not allowed to change or vary the system in any way. Technical changes need explicit written approval of *INDUTHERM Erwärmungsanlagen GmbH*.

The casting machine must not be placed in areas with explosive atmospheres.

Predictable abuse:

- Warming of human body parts on hot surfaces.
- Heating and casting of others then the mentioned metals.

2.2 Demands on staff, duty for utmost care

Work on and with the machine is allowed to be accomplished by reliable, trained and instructed staff only. Responsibilities for the separate sections have to be regulated clearly which include operation, preparation, service and repair.

Only authorized personnel may act at the system.

The machine may never be operated by personnel under influence of reflex diminishing medicine or people not able to work because of illness or disorder.

Running of the system has to be always supervised by trained staff.

Personnel which have to be trained und introduced to this job or within in the course of vocational training may work only under permanent observation of a person experienced with the machine.

Work on the electrical equipment is only allowed for workers skilled in the field of electricity.

The instruction manual has to be freely disposable at the location of the system. The employees have to know the storage place.

Every person working at the system has to read and apply the instruction manual especially the safety advices. The personnel have to read and understand the chapters referring to safety aspects for the particularly components of the machine. Please read before beginning the work.

Please control the personnel for paying attention to all facts of safety and danger prevention.

2.3 Protective measures

This operator’s guide contains all important advices to operate the system secure.

Basic prerequisite for safe dealing and trouble-free running of this system is the knowledge of fundamental safety advices and industrial safety rules.

In commercial facilities you have to regard the accident prevention regulations of the professional association for electrical systems and tools.

The internal regulations of industrial safety are to be observed.

2.3.1 Concept of safety

Objective is the safety:

- of the staff against injuries;
- of the system against damage or standstill and
- of the environment against endangering.

The list of actions taken:

- deployment of protective equipment like covers and mains switch; you can unplug the mains plug as an emergency stop. The wall socket for the mini-casting unit MC16 must be freely accessible.
- water-cooled inductor housing;
- duty of wearing personal protective equipment (PPE);
- affix safety markings on the installation;
- create safety advices in the manual.

2.3.2 Protective gear

Protective gear (PPE) includes:

- heat-resistant clothes,
- heat-resistant, closed shoes,
- heat-resistant protective gauntlets protecting artery and
- face guard.

Caution!

Wear always for every process step the right protective gear.

2.3.3 Safety equipment

The safety of the machine is only guaranteed if all safety equipment is proper installed and working proper. Don’t use the system without the safety equipment!

Disassembling safety equipment is only allowed in power supply free state (mains switch in off-position, mains plug disconnected and placed in sight). Install every part of the safety equipment after repair. Perfect function has to be checked.

Caution!

Safety equipment protect from unintentional access of the staff to danger spots. They prevent possible injuries. Never manipulate the safety devices!

2.3.4 Safety markings on the unit

A necessary condition for safe dealing with and undisturbed running of the machine is the knowledge of safety instructions and industrial safety regulations.
At the machine casing the following safety markings are attached.

safety marking	meaning	safety marking	meaning
	Warning of dangerous electrical voltages.		Wear heat resistant safety clothing.
	Warning on hot surfaces.		Wear heat resistant protective gauntlet gloves protecting artery.
	Forbidden for persons with pacemaker.		Wear face guard.
	Read instruction manual.		Wear protective shoes.

Advice

Keep the safety markings always clean. Replace the markings if they aren't recognizable. Observe the warnings and commands. Don't expose yourself careless to dangerous situations.

2.4 Safety marking

The following signal words are used in this document which are associated with safety markings for presentation of possible dangerous situations.

Danger!
Death, serious body injury or substantial property damage **will result** if proper precautions are not taken.

Warning!
Death, serious injury or substantial property damage **can result**, if proper precautions are not taken.

Careful!
Minor personal injury can result if proper precautions are not taken.

Danger!
Property damage can result, if proper precautions are not taken.

Information/advice
Here you get information and advices to carry out the following activities effective and safe.

2.5 Safety advices

Check always the condition of the system before you switch on the system. Examine the supply pipes and insulations if there are leaks and damages. Operate the system only if it is in proper and faultless shape.

Operate the system never:
- if there are malfunctions,
- if it is showing damage or
- after heavy transportation stress.

The system has to be constantly controlled when running to be able to recognize and avoid dangerous situations. The system may not run if it is unsupervised.
Do never change, remove or close the safety valves inside the machine.

Danger!

Danger to life because of strong electromagnetical fields (induction). For persons with pacemaker it is not allowed to approach or to be near to the machine.

Danger!
Danger to life are caused also by the fact that very hot and liquid metals solidify in cold liquids. In this case, may arise physical and chemical reactions that have to be previously analysed by the user. During this it can emerge physical and chemical reaction, which is to be evaluated by the operator.

Warning!

Risk of burning on hot surfaces and hot metal (until ~ 2000 °C). Wear always personal protective equipment when you work with the machine.

Utmost caution during using graphite crucibles and graphite moulds. The heat of these parts is only visible when the temperatures are over 500 °C.

Warning!

Maintenance and servicing of the machine only when the system is disconnected from the mains supply (Pull out mains plug).

Advice!

Don’t disconnect mains plug, while machine is running or in standby. Switch off for pulling out or putting in mains plug.

Danger!

Risk of burns. If metal is melted without the supply of protective gas, can cause a flash fire or explosion when opening the bell.
Melt at temperatures above 500 °C always with protective gas. Use as a protective gas exclusively argon or nitrogen

Danger!

Danger because of touching parts conducting voltage.

Work on the electrical equipment is only allowed for authorized qualified staff.

Access to the electrical distribution box is only allowed for authorized qualified staff with tool.

Work on the electrical equipment is only allowed when the system is disconnected from power supply (pull out mains plug).

- The capacitors can retain their charge even after deactivation of the system.
- Keep the housing of the mini-casting unit closed continually.
- No work must be carried out on parts conducting high voltage.
- Remove loose connections.
  Replace immediately damaged scorched or slightly burned cables. Perform work only when mains plug is pulled out.
- Cables may not wedge in or rather squeezed. Cables have to be laid in a way that they not become a tripping hazard or can be not damaged.

Danger!

Threat of health injury by escape of medias from damaged hoses. Danger of system damages.

- Remove loose connections. Replace damaged hoses immediately. Perform work only when mains plug is pulled out.
- Hoses may not wedge in or rather squeezed. Hoses have to be laid in a way that they not become a tripping hazard or can be not damaged.

Warning!

Risk of burns:

- burns because of squirting liquid metal and
- burns at hot surfaces.

Warning!

Danger of explosion.

Dripping liquid metal can't be excluded.
The set-up place (table) and the floor beneath the system should be made of non-flammable material. As well there shouldn't be stored inflammable materials within a radius of 5 metres.

Attention!

At crucible temperatures over 100 °C the cooling water supply must be switched on. If it is not turned on, the inductor will be destroyed. If cooling water supply fails, the heating system immediately is turned off. Inspect the system for damage before putting back into operation again.

Danger!

Lethal injuries happen because of false transport by forklift truck.

- Pay attention of the right attachment of the means of transportation, otherwise the system can fall from forklift truck.
- With too small dimensioned or forks adjusted too narrowly there is danger for the system to fall from the means of transportation.
- Wear appropriate personal protective equipment (PPE).
- Move the system only by skilled personnel qualified for transportation jobs.

For damages resulting from non-compliance of regulations in transit there is no assertion possible for warranty claims.

Warning!

Danger of burns by leaking liquid metal.

Warning!

Health risk because of lifting heavy weight.

Lift and transport the machine only by two persons.

Warning!

Risk of injury.

Make pressure leading system parts depressurized before you carry out servicing.

Warning!

Risk of slip on the floor around the installation in case someone had spilled lubricant or solvent.
Clean the floor from dirt immediately! Dispose cleaning tissues in the specific collecting boxes.

Caution!

Observe regulations for the mains supply written from the responsible electric power supply company, the association VDE and the local electric power station.
Inappropriate connecting can lead to injuries and damages of the machine.

Caution!

Danger for health because of inhalation of fibre particles.

- Store the vacuum chamber insulation in dustproof package.
- Remove the material just before installation.
- Pack the materials immediately after removal dustproof and dispose the materials in this packaging.

2.6 Residual risks

risk characterisation	risk reduction
Health risk for persons with cardiac pacemaker who approach the running system.	Instruct people.
Burn injury on hot surfaces or hot molten metal.	Teach people.
Danger of explosion because of dripping of liquid metal in a water filled steel tub during melting of aluminium or aluminium-alloys.	Fill the tub with sand.
Jet flame or explosion when opening the lid of the melting chamber in case of melting without protective gas.	Always melt with protective gas at temperatures above 500 °C.
Tilting and toppling of the system due to improper transportation.	Consider shipping instructions.

2.7 Behaviour in an emergency

The personnel working at the installation must be trained about the behaviour in an emergency.

All persons who are working with the machine must be informed of the possibility of rapid standstill of the device.

3 Technical Data

	MC16
Crucible volume (1)	15 cm^3 (ceramic crucible) 10 cm^3 (with graphite inlay)
Pressure range in melting chamber in bar	-1 to 2
Crucible temperature in °C	max. 2000
Melting performance in kW	3.5
Mains supply	230 V, 50 or 60 Hz
Fuse protection in A	16
Abduct current in mA	4.45
Thermocouple	Type N (NiCr-Ni), max. 1300 °C Optional type S (PtRhPt) max. 1400 °C
Cooling water supply	Øa 6 mm, 2.5 - 5 bar / min. 1.5 liter/minute, max. 6 °dH
Cooling water recoil	Øa 6 mm, pressureless
Cooling water entry temperature	15 - 25 °C / 59 - 77 °F
Ambient temperature	10 - 35 °C / 50 - 95 °F
Relative humidity	20 - 80 %
Protective gas supply	Øa 8 mm, argon or nitrogen, 6-8 bar
Vacuum	Øa 8 mm, min. 8 m^3/h, 0.1 mbar abs.
Weight in kg	ca. 27
IP Code International Protection Marking	IP20
Dimensions in mm (Wide x Depth x Height)	400 x 450 x 400
Maximum melting temperature	Depends from used thermocouple: type N (NiCr-Ni): 1300 °C type S (PtRhPt): 1400 °C
Noise emission in dB (A)	72

(1) These are standard values which can be changed optional.

4 Description of the system

4.1 Components of the system

The system consists of several modules assembled in one housing.

Inside the housing there are:

- mains cable,
- microprocessor controlled induction generator DM-type,
- middle-frequency transformer,
- oscillating circuit capacities and
- pneumatic (magnet-) valves.

The front plate contains:

- front panel for control of the casting process.

To the melting system belongs:

- inductor housing, water cooled with inductor, crucible, insulations and thermocouple.

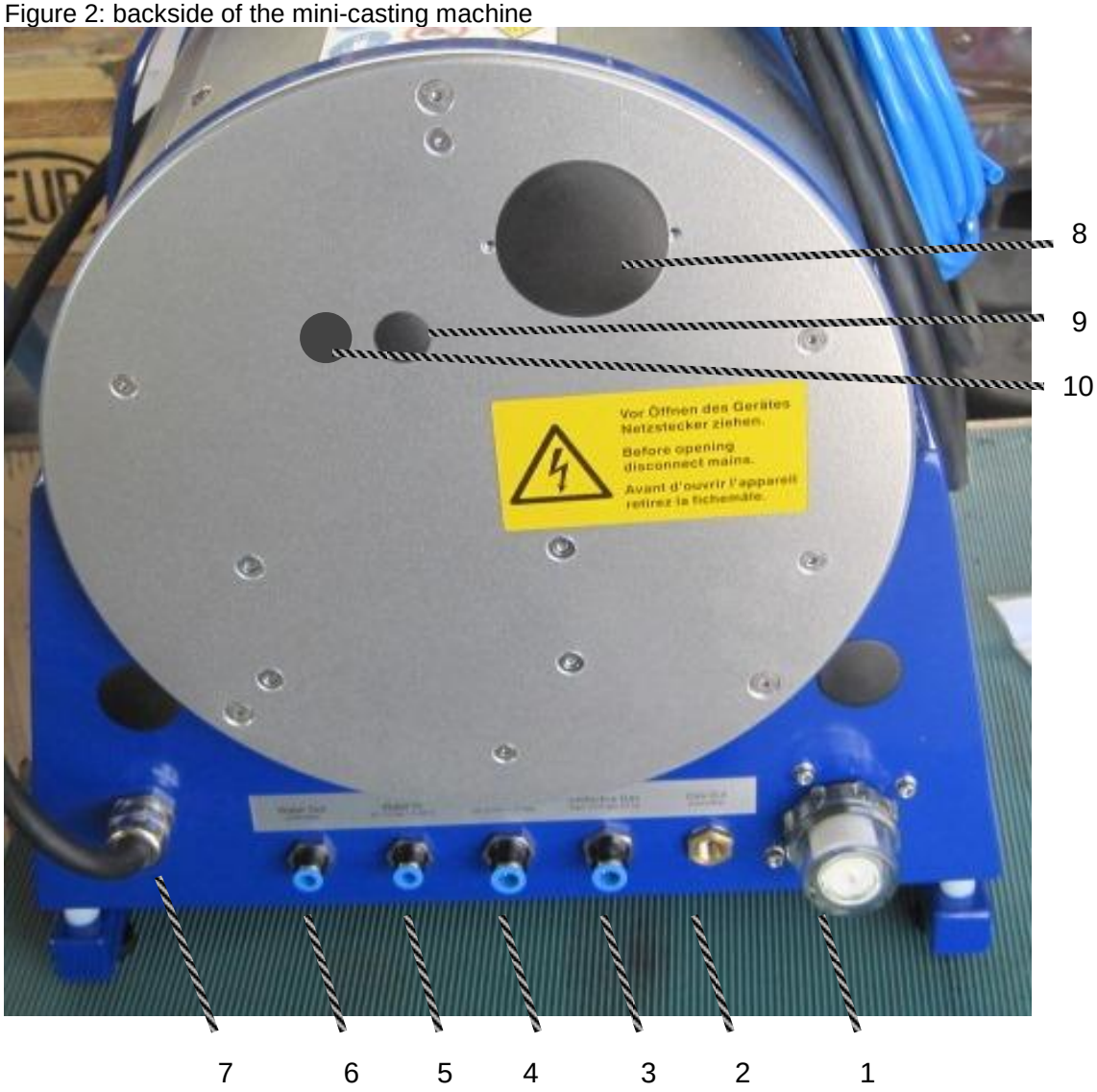
4.2 Schematic representation

Figure 1: overall view

Position	Description	Function
1	tilting handle with lock	Due to movement to the right the machine will cast.
2	inductor housing	The melting and casting process takes place here.
3	control buttons.	Control the casting process. See ch. 4.6.
4	LCD screen	See chapter 4.5
5	top plate with handle	Locks the inductor housing.
6	lock	Locks the system for safety reasons and to allow overpressure.
7	mains switch	Machine will be turned on and off here.

4.3 Connections on the backside

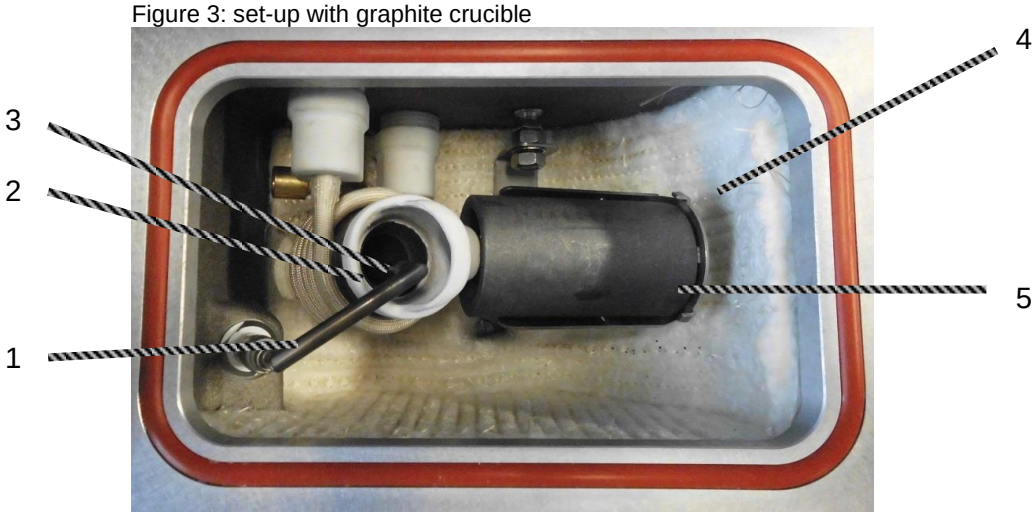
Figure 2: backside of the mini-casting machine



Position	Description	Function of the connection
1	vacuum filter	filters the vacuum
2	Gas out	gas outlet
3	Protective gas	input for protective gas
4	Vacuum	connection for external vacuum pump
5	Water In	input for cooling water
6	Water Out	output for cooling water
7	mains cable	electrical connection for machine
8	RS232 connection	connection for PC or modem for service issues
9	Ethernet	connection for Ethernet-cable (RJ45) for service
10	USB-B-socket	connection of USB cable for service issues

4.4 Set-up in the vacuum chamber

Figure 3: set-up with graphite crucible



Position	Description	Function
1	thermocouple type S	Allows a temperature measurement up to 1400 °C.
2	ceramic crucible with graphite inlet	In this crucible the graphite contains the heat and transfers the energy to the metal.
3	ceramic cover	Protects the thermocouple against contamination with liquid metal or graphite.
4	Flask adapter	Adapter for various flasks and mould sizes.
5	Mould	Here graphite mould. You can use flasks too.

4.4.1 Different crucibles

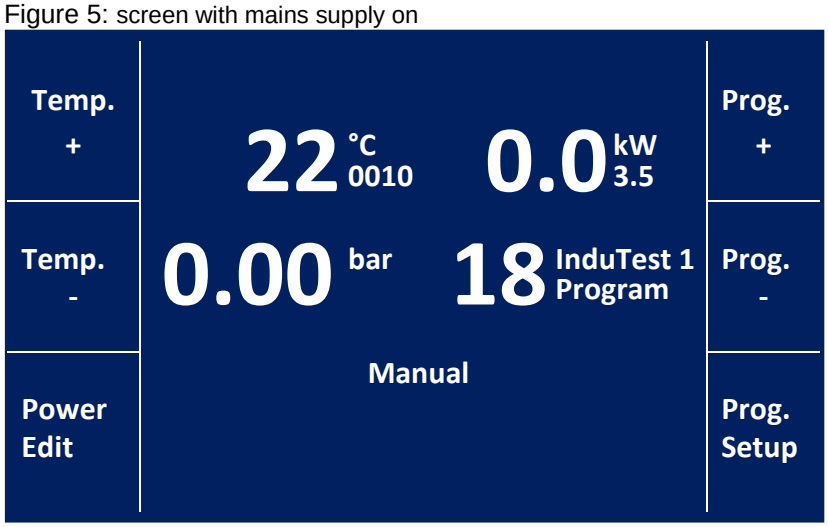
Figure 4: types of crucibles

Ceramic crucible with graphite inlet for precious metals	Ceramic crucible for platinum and other high temperature alloys	Ceramic crucible for CrNi, CrCo and other steel alloys
#12279021.	#12279030	#12279020.

4.5 Front panel display

4.5.1 MC16 screen when starting the machine

Figure 5: screen with mains supply on



Display in the middle section:	
22 °C	actual temperature
0010 °C	set temperature.
0.00 bar	actual crucible pressure (-1 to 2.0 bar)
0.0 kW	actual heating power in kW
3.5	maximum heating power in kW
18 Program	active program
InduTest 1	program name
Manual	casting mode

On the left side shown:	
Temp. +	Rise the set temperature even within a program.
Temp. -	Lower the set temperature even within a program.
Power Edit or Temp. Edit	Changes display to achieve temperature or power controlling.

On the right side shown:	
Prog. +	Go to the next program (here program 19).
Prog. -	Go to the next program one place lower (here program 17).
Prog. Setup	Level to modify the selected program (here program 18).

4.5.2 MC16 modify program screen

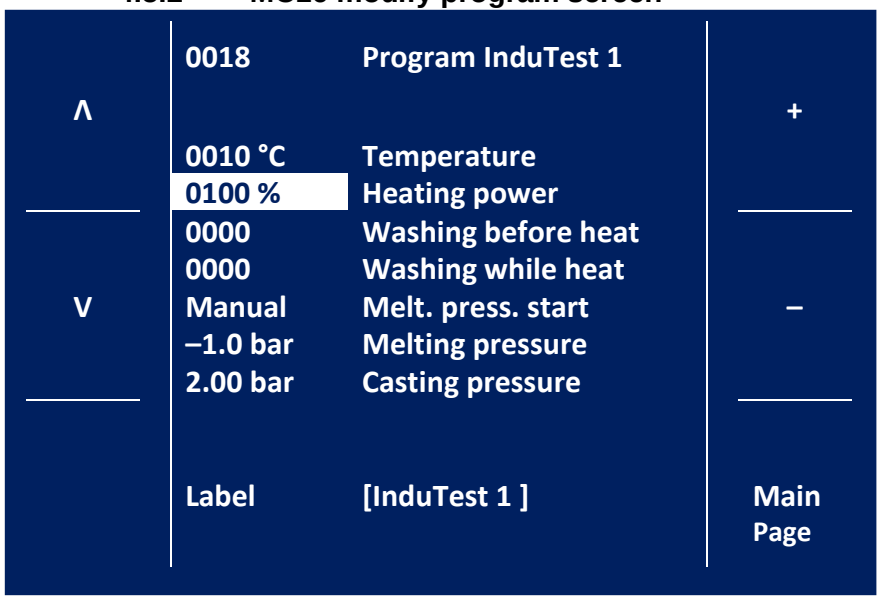


Figure 6: program parameter

middle section with program parameter

Outer area with choice

Display in the middle area:			
0018	InduTest	‚0' to ‚19'	Selected program to modify.
0010 °C	Temperature	‚10' to ‚1300'	Set temperature inside the crucible.
0100 %	Heating power	‚10' to ‚100'	You can reduce heating power here.
0000	Washing before heating	‚0' to ‚5'	Washing cycles before heating (starts with vacuum, then backfill to 0.0 bar with protective gas). Number displays the cycles that will be done. It is recommended for palladium alloys (very reactive).
0000	Washing while heating	‚0' to ‚5'	Washing cycles during the machine heats.
Manual	Melting pressure start	‚Automatic'	Start of the melting pressure. Pressure starts after the washing cycles.
		‚Manual'	To start melting pressure, you need to press the start button again.
–1.00 bar	Melting pressure	‚-1.00' to ‚0.00' bar	Melting pressure set value in chamber during heating.
2.00 bar	Casting pressure	‚-1.00' to ‚2.00' bar	Casting pressure set value.
Label	[InduTest 1]		Here you can change the name of the program.

Display on the side:	
Λ	Moves the input area (highlighted area) one level above.
V	Moves the input area one level below.
+	Increases the value within specified limits.
-	Decreases the value.
Main page	Display returns to main menu.

4.5.3 MC16 modify system parameter

If you start from the main page and you press “Program Setup” for 5 seconds you get access to the system-parameter level.

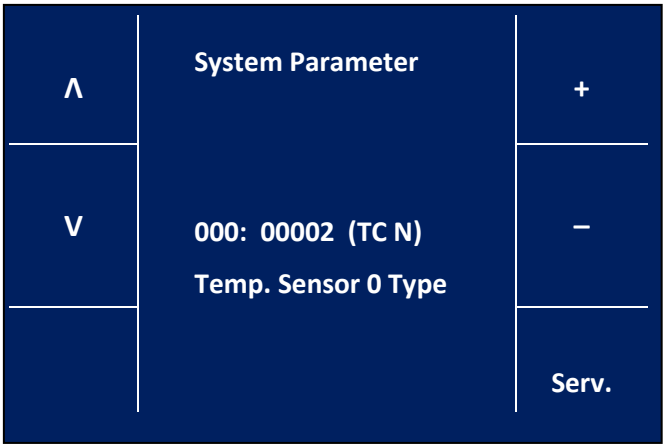


Figure 7: System parameter

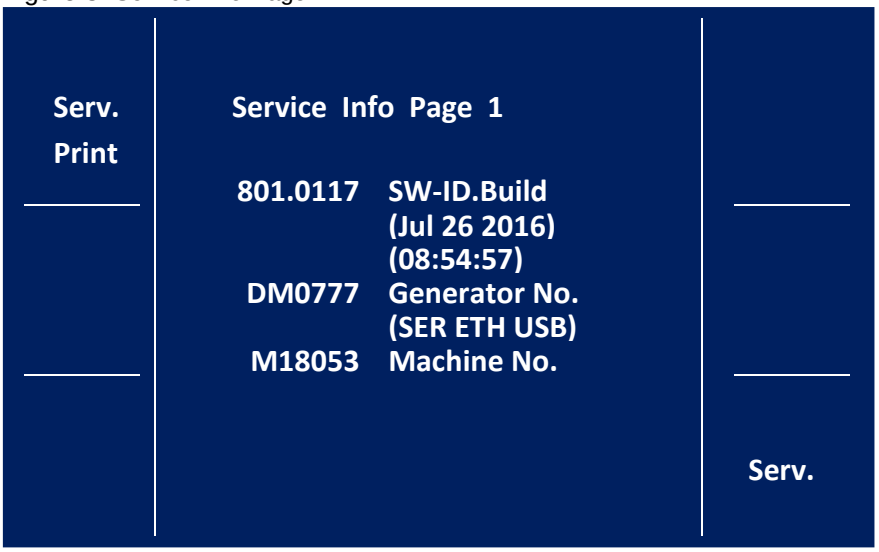
Note:
Please refer to the explanations for the parameters in the attachment software documentation. The adjusted values should be changed with care and usually after consultation with the Indutherm service staff.

Display-functions:		
000:	00002	Selected parameter: 000. Value of parameter is 2, which means here thermocouple type N (TC N) is activated.
V		With pressing ‘arrow down’ you get to previous parameter (here not possible).
Λ		With pressing ‘arrow up’ you get to next parameter 001.
-		With pressing ‘-’ you decrease the value to 1.
+		With pressing ‘+’ you increase the value to 3.
Service		With pressing the button near to this word, you see information of ‘Service Info Page 1’ with several serial numbers.

4.5.4 MC16 State-Level (Service Info Page 1 + 2)

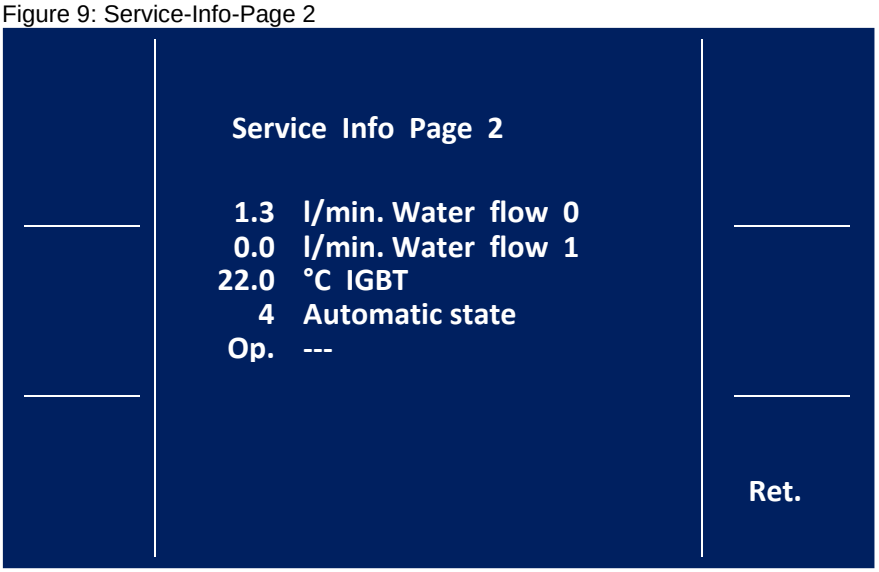
If you press “Serv.” in system parameter menu, you’ll see software ID, generator no. and machine no.

Figure 8: Service-Info-Page 1



If you press „Serv.“-button again, you’ll see cooling water flow (sensor 0), generator temperature (IGBT) and actual machine state. The rows ‘Water flow 1’ and ‘Op.’ are not used in MC16. The button ‘Serv. (Service) Print’ is without function.

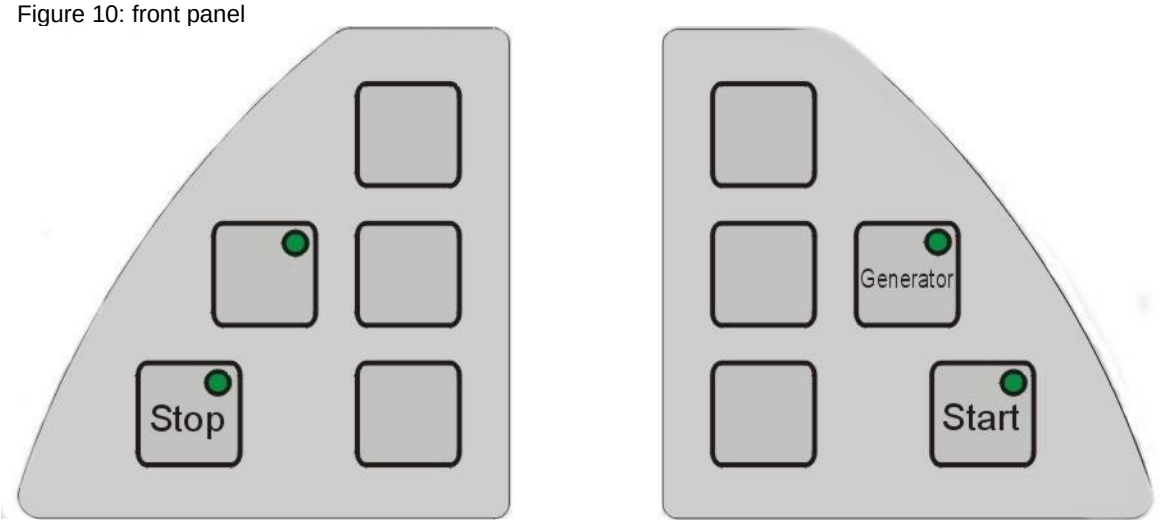
Figure 9: Service-Info-Page 2



With pressing of button ‘Ret.‘ you can return to main menu.

4.6 Front panel buttons

Figure 10: front panel



From left to the right

Button	Function
Stop	Stops active program.
6 push buttons left and right from display	Function of these buttons you can see in display. See chapter 4.5.2 too.
Generator	Starts and stops heating with induction generator outside the automatic mode.
Start	Starts selected program. Second push starts melting pressure in manual mode.

Special function of "Start" button:

If you are operating within a program cycle and melting pressure is active, you can release and reactivate the melting pressure by pressing the start button.

4.7 Functional description

With the casting machine, castings of different dimensions can be produced from the metals to be used as intended. For this purpose, the casting material is first melted inductively under a protective gas atmosphere and then poured into a flask or into a mould.

The advantage of the inductive heating is the rapid attainment of the melting temperature, since the heat is generated directly in the melt material and in the crucible. Likewise, the metal is thoroughly mixed through the magnetic field during the melting process, so that homogeneous metal mixing is achieved even in new alloys.

The built-in thermocouple is used to precisely measure the temperature and to control the power of the unit so that the set temperature is kept constant.

The material is melted as standard with protective gas purge. For metals, which are more susceptible to oxidation, it is recommended to draw vacuum after the material has been filled, and subsequently to return with protective gas. In addition, in the case of metals with a high oxygen content (eg commercially available copper or silver), degassing of the molten metal under vacuum is possible.

The INDUTHERM mini casting machine MC16 is suitable to cast all kind of metals into moulds or into investment flasks. Exceptions are dental alloys and very reactive alloys like magnesium. The melting charge is heated up by induction. The special advantage of strong inductive heating is that the melting temperature is reached rapidly, because the heat is directly generated in the metal or will transported to the metal by a crucible with graphite insert. During the melting process, the metal is thoroughly mixed by means of a magnetic field, ensuring a homogenous mixing even when using mixtures of pure metals.

Crucibles with graphite inlet are used for metals up to 1300 °C and ceramic crucibles for steel or platinum up to 2000 °C.

Vacuum-Pressure mode in only one chamber

The casting mode is based on this new method: during the melting process the metal and the flask are under full vacuum. The metal is poured into the flask by tilting the whole chamber. Inside flask is also a vacuum which guarantees pouring without air counter pressure. Now the vacuum will be replaced by gas overpressure rapidly: The pressure impulse (inside of the flask is still under vacuum!) ensures excellent form filling. The effect of vacuum in the flask and outside overpressure lasts for some time, long enough until metal is already solid.

The most important fact of this system is quickly creating of vacuum and very fast pressure built-up in the system. To the evacuate chamber it needs a strong vac pump with 8 m^3/h minimum, releasing vacuum + creating over pressure it needs a gas bottle with PRESSURE regulator (NEVER a flow regulator !!!). Short connection pipes make rapid pressure supply even better.

All functions are linked with the turning of the chamber: immediately after pouring metal into the flask, over pressure comes automatically.

As mentioned before, a pressure impulse on top of liquid metal, while inside there is still a vacuum, makes the good form-filling of this system. This means, the flask by itself is a reservoir of the vacuum. As smaller the flask, as less reservoir is there and pressure equalisation is quicker. In case of doubt (very delicate items) or form filling problems take one size bigger for the flask than necessary from aspect of dimensions.

4.8 Casting programs for MC16 (05.12.2016)

Figure 11: predefined casting programs

MC16								
Material		**Silver 935**	**Yellow gold 18k**	**Test 1**	**Test 2**	**Platinum 950**	**Stainless steel CrCo**	**Palladium 950**
Crucible		Graphite	Graphite	Ceramic	Ceramic	Ceramic	Ceramic	Ceramic
Temperature reading		Thermocouple	Thermocouple	without	without	without	without	without
Program No.		**10**	**11**	**18**	**19**			
Temperature*	°C	1000	1050	10	1200	***	***	***
Heating power	%	0050	0050	0100	0100	0100	0100	0100
Washing before heating		0000	0000	0000	0000	0000	0000	0001
Washing while heating		0000	0000	0000	0000	0000	0001	0000
Melting pressure start		Manual	Manual	Manual	Manual	Manual	Manual	Manual
Melting pressure**	bar	-1.00	-1.00	-1.00	-1.00	-0.80	-0.90	-0.80
Casting pressure	bar	2.00	2.00	2.00	1.00	2.00	2.00	2.00
Label		935/Ag	750/YG	Indu-Test 1	Indu-Test 2	950Pt	CrCo	950Pd

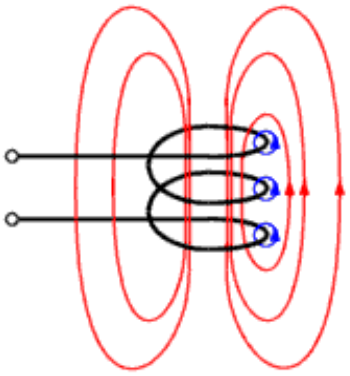
*	Temperature: Please see the alloys data sheet for recommended casting temperature.
**	Melting pressure: When the display shows “Melting”, the melting pressure can be applied at any time by pressing the “Start” button again.
***	Casting should be done as fast as possible. The temperature setting doesn’t matter here. The casting needs to be done by vision. Once the material is liquid wait 5-10 seconds and then cast!

4.9 Direct induction heating in ceramic crucible

Direct induction melting is necessary on metals with high temperature melting points, such as Pt., steel etc. High temperatures do not allow use of graphite crucibles because of quick burning under standard atmosphere. Also, direct induction melting is necessary on metals, which reacts unwanted with graphite.

An Induction Coil, used in our systems, creates streamlines of electrical field, with a specific direction.

Figure 12: field line profile in an induction coil



If now a conductive material like metal is brought into this induction field, metal absorbs energy, it couples. This metal is separated in a nonconductive ceramic crucible in between.

As bigger now the working surface of the metal, as more energy can be absorbed, as quicker melting can happen.

This is why metal parts should be placed rectangular to field line = horizontal, to provide optimal absorption of energy.

So it makes sense to place metal plates horizontal, also bigger wires couple more energy in horizontal position.

Figure 13: typical application which not work

This is a typical application what does not work with a MC16.
Here are 20 g of small thin Platinum sheets.

Miscues:

- 20 grams of Platinum melt only as one piece
- the material is standing vertical (IIII).
  Much better would lying horizontal (==) to cross fieldlines!

Please also take notice, that induction melting systems need a certain amount of volume to absorb enough energy for melting. The MC16 with direct induction heating needs a filling level of at least 20 % of the crucible's volume. Thin wires, chipping do not have enough volume and should be compressed (by a press) or better, charged into already melted liquid metal. Caution, Danger of splashing!

When using cast-iron plates, care must be taken that they lie horizontally, parallel to the crucible base to achieve a good inductive coupling. Even short cast-iron cylinders can be warmed flat better. Please take care that this metal parts have enough distance to crucible's wall to prevent disruption of crucible by extension of the metal pieces before melting.

At direct induction melting please notice following hint:

If a too voluminous piece of metal will be added to an already molten metal, molten metal can “freeze”, it becomes solid again. If this form-fitting metal now is heated-up again, it expands can disrupt the crucible. Hint: load complete amount of metal in cold crucible or charge only small pieces into molten metal. Caution: danger of squirting!

Direct melting is usually used for metals with a high melting point.
Often (as in the case of, for example, platinum), the ceramic coating material is at the limits of its thermal compatibility. Therefore, melt as soon as possible and drain immediately. To play with liquid platinum strikes the ceramic immensely and shortens the life of the crucible.

4.10 Temperature control

To use the temperature controller a thermocouple

type N article no 13400010 up to 1300 °C (parameter P.000 - must be set to 0002)

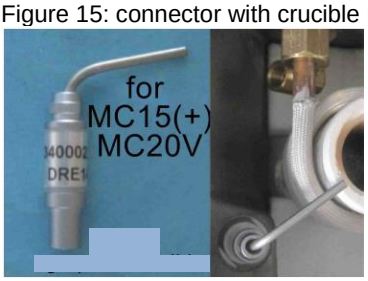
or

type S article no 13000030 up to 1400 °C (parameter P.000 - must be set to 0001) has to be connected to the socket inside the casting chamber. Very important is that you use the thermocouple together with the thermocouple protection cover article no 13200045.

Figure 14: thermocouple with protective cover

Important: Use thermocouple for melting only in crucibles **with graphite inlet**. Otherwise induction energy will stimulate thermocouple directly (without protection by graphite). Result, read in display, is pure nonsense!

Figure 15: connector with crucible holder



Item no. 13400022 – connector with crucible holder for using power control instead of temperature control. Another name is dummy plug.

The nominal temperature can be set with the buttons "Temp. +" and "Temp. -". The heating power is now controlled by the temperature controller. If the temperature control is not in use (e.g. for temperatures above 1400 °C, platinum alloys) the dummy plug must be connected to the thermocouple socket. The machine automatically switches to the manual heating power mode. The heating power can now be adjusted with the buttons "Power +" and "Power -" (display shows 0.0 kW (0 %) or 3.5 kW (100 %).

Information!

Without thermocouple, without dummy plug or with defective thermocouple the display shows "E041". The machine detects automatically change from thermocouple to crucible holder within 20 seconds after pressing Start/Generator-button. From crucible holder to thermocouple machine needs 5 seconds for detection after START. At this moment the heating power will be set to 50 % (1.7 kW) according to program and parameters.

Attention:

Do not use a thermocouple in direct heating process! Energy will melt thermocouple! If you use graphite crucible and thermocouple the output power must not exceed 50 % (1.7 kW). Otherwise the temperature overshoot is too high and will burn the thermocouple.

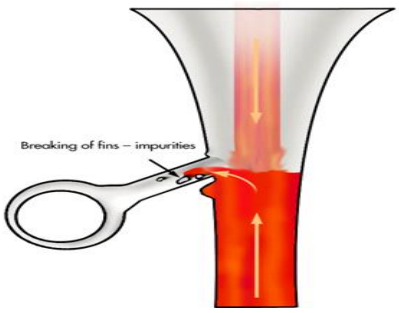
4.11 Tree making

Pieces made of wax/plastic must be placed in “tree”-shape. This is done by a small soldering needle + wax wire at (wax-) center sprue. This main sprue is fixed in the rubber base, the diameter of the rubber base is according to the diameter of the flask. On bigger trees for bigger machines there is a main wax sprue (ø 8-10 mm). On this main sprue single pieces are fixed in a style of a spiral. This is best for cutting off the casting pieces after casting process. On MC16 this tree is more a bush, pieces are fixed on the button cone directly. Only a short piece of main sprue is required.

Some hints for the topic “tree making”:

- Make sprues as short as possible.
- Diameter of sprues should be big enough to guarantee optimal feeding of the castings with liquid metal.
- The middle trunk should be as thick as possible to ensure proper supply of the cast parts with liquid metal.
- Place wax pieces so that wax can flow out easily.
- The connection of the waxes to the sprue should be done in a hydro-dynamic style, to prevent turbulences while pouring liquid metal.

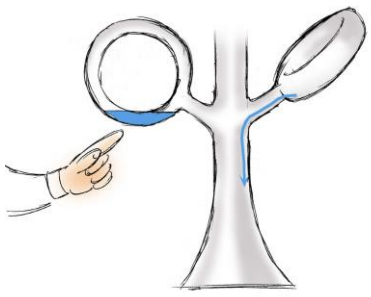
Figure 16: hydrodynamic not proper style



Liquid metal is heavy; it can break away thin parts of the gypsum. Create all connections in hydrodynamic proper style

Figure 17: tree with easy flow of wax and not

Not good



good

- Do not place waxes/plastic parts to close to flask cylinder. There should be a distance of at least 5 mm.

4.12 To find out the weight of the metal

All rubber bases must be determined on a scale. Write exact weight on this rubber bases by a felt pen.

After mounting the tree, take the total weight. Deduct the rubber base weight from the total weight = net wax weight. To simplify matters we assume the specific weight of wax as 1.

Metal weight is calculated by multiplying wax weight by the specific weight of the metal:

Metal	Spec. weight in g/cm³
Water, wax	1.00
Aluminium	2.70
Steel	7.85
Brass	8.40
Bronze	8.80
Silver	10.50
Nickel silver	8.40
Gold 333	10.90
Gold 585	13.70
Gold 750	15.20
Gold 900	17.40
Palladium 950	12.00
Platinum 950	20.70

Example:

Complete weight (wax + rubber base) 43.5 g less weight of rubber base 38 g = 5.5 g wax.

5.5 g wax means

Metal	Wax weight in g x Specific weight	Metal weight in g
Silber	5.5 g x 10.5	57.75
Gold 750	5.5 x 15.20	83.60

- After the calculation: Place flask cylinder and fix it carefully on the rubber base. Do not touch wax pieces. Mark the rubber bases clearly to avoid confusion when you prepare several flasks!

4.13 Using already cast material

Because of high costs casters do not like to use every time fresh alloy. For some alloys customers mix “second hand metal” up to 50 %, mainly Au, Ag based alloys. Please pay attention to following:

- Never use finished jewellery pieces. The alloy composition is not known, solder in casting material will give no good casting result.
- Never mix two alloys, even if they have the same contents of gold.
- All already cast metal should be very clean, sand blasting and pickling are adequate methods. Caution: rest of glass beads, investment material or rests of acid are unwanted. Acid residues can be cleaned in ultrasonic bath wih distilled water.
- Alloys with zinc content: give a little bit more fresh metal to “old” metal.
- Alloys with high carat (Pt. 950, Au 21/22/24 kt) can be re-used to 100 %
- Pd 950 is a very reactive metal. No chance to melt it twice. Use fresh metal!
- Prevent oxidation by melting under vacuum and protective gas only.
- Never use boric acid for melting!

4.14 Notes on the properties of some metal alloys

Brass, gold 8/9/10 kt, some alloys gold 14 kt	These alloys have a high content of zinc. Some of the zinc evaporates during the heating phase. If vacuum is used in the melting chamber, much more zinc would evaporate. To prevent this problem there is a small trick: Put the metal in the **cold crucible**, set in flask at the same time. Push button start (heating) and start (vacuum) again immediately. Now a vacuum is built up, but the metal, still not liquid, cannot evaporate zinc. After reaching full vacuum, push another time start (vacuum will be released by gas). After reaching casting temperature, cast immediately.
Palladium 950 	Palladium should be melted in the same type of crucible like platinum. Palladium has a strong reaction with oxygen. That´s why we recommend to “wash” the chamber atmosphere as follows: Set “power” to 0.0 kW (0 %). Put in metal, set in flask. Push button **Start** (want to heat, but set point power is zero = no heating possible). After then **Start** again = vacuum comes. After reaching vacuum, another push on **Start**: vacuum will be released by ARGON gas. Make only ONE washing cycle, because palladium extracts the oxygen from the crucible ceramic. Change setting of power to 3.5 kW (100 %). Wait until metal is molten completely and cast immediately. **IMPORTANT: Use Argon gas for palladium castings!**

Platin	Set heating power to 3.5 kW (100%). Use the special ceramic crucible for Platinum. Put metal into the (cold) crucible. Push “Start” once for heating, set in flask and lock chamber. Push “Start” second time to start the vacuum. Full vacuum is reached inside the gypsum in about 30 seconds (see timer). After metal is melted totally, wait for max. 8 seconds and cast. This will extend the life time of the crucible! Adjust your process in that way, that in the moment of pouring out the Pt. and the end of evacuation time (at least 30 seconds) of the flask are concurrently. Important hint: Pt., melted in a standard Pt.-crucible, is absorbing silicate out of the crucible material. As more often you re-melt same batch of metal, as more silicate will be absorbed. This makes Pt. brittle. Help: Coating of the inside of the crucible by use of liquid zircon oxide! After casting: leave flask under set parameters for approx. 240 seconds.
Cobalt-chromium, steel alloys	Set heating power to 2.8 kW (80%). Use the ceramic crucible for steel. Put in crucible, set in flask. Push “Start” twice to start heating and vacuum. If full vacuum is there for at least 30 seconds (see timer) increase heating power to 3.5 kW (100 %) and cast when metal is ready. One more problem of NiCr, CoCr and steel alloys: some alloys tend to splash in melted condition and under vacuum. In this case, it is useful to change setting of melting pressure to -0.80 bar.

4.15 Investment material

Generally, there are three types of investment:

Gypsum-bonded investment materials for metal temperatures up to 1250 °C. (Flask temperature up to 730 °C) These are standard investment materials for gold, silver, bronze, etc. These investment materials are stirred with water and the investment is easy to remove by quenching in water.

Phosphate-bonded investment materials for higher temperatures
These investment materials are applied with water and are suitable for metals up to 2000 °C metal temperature (flask temperature up to 990 °C), ie for steel, palladium 950, platinum. These investment materials are stirred with water.

Disadvantage: Most difficult to remove. After pouring, the cuvette is to cool and the investment mass is then coarsely removed with a hammer. A sand blasting machine with corundum medium is very helpful.

Due to legal regulations, it is not advisable to use acids to clean the castings.

Dental investment materials usually have especially good properties in terms of shrinkage and shape contrasts. These investment materials are often mixed with acid.

Disadvantage: Very expensive. Most difficult to remove. After pouring, the cuvette should cool and the investment mass is then removed roughly with a hammer. A sand blasting machine with corundum medium is very helpful.

Due to legal regulations, the use of acids for cleaning the cast trees is not advisable.

Each manufacturer has a variety of investment materials in the program. This means that comprehensive information about the properties is necessary. Your specialist dealer can be a suitable contact person. Please read the instructions carefully for use so that important details such as mixing ratio, water temperature and processing times are meticulously strictly adhered to. Investment compounds should only be purchased from reputed traders. Investments have a limited life.

Investments are all hydrophilic, that is, open containers accumulate with moisture. A good solution: store the embedding embedding compound in chemical whiskey bottles. A few dry bags (as in packs of electronic devices) help here.

Investments are a mixture of different powders. A long transport with the ship or truck can change this mixture. Heavy parts sink down, light parts float on top. In production companies, whole containers are often homogenized in a cement mixer. It is also sufficient to put the drum upside down and shake it.

4.16 Investment process

Investment process means, that powder is mixed for a certain time with water in a special ratio into slurry and filled into a flask.

This stirring can be done in an open bowl with a spatula. However, air is also introduced = bubble formation in the investment material = bubbles on the surface of the wax plastic parts after embedding. The mixing of the investment material with the water should therefore be carried out under vacuum.

If investment material is stirred and then filled into the flask, air bubbles are also expected on the parts, even if the filled flask is then placed in a vacuum: is likewise not very successful. There is also a vibrator of little help.

- Mixing under vacuum helps to avoid air bubbles.
- Filling under vacuum + vibration helps to avoid air bubbles.

When both operations happen in one machine: Optimal.

Please note:

- As already explained: the mixing ratio investment material and water is very precisely defined. If the final, still liquid embedding compound is left under vacuum for a long time, the bulk water is removed i.e. this mixing ratio will change! The reason for this is that water under vacuum has a boiling point at room temperature. Ascending bubbles in the liquid investment material are not blowing with air bubbles: They are bubbles of water vapor! Therefore important: Release vacuum immediately after filling.
- The liquid investment material requires a certain time to set (approx. 1 hour). The beginning of the setting phase (the surface becomes dull) starts much earlier. During the complete setting phase, the flask should rest in a quiet and vibration-free place. In the case of the "manual" method (mixing + venting under vacuum + filling into the flask + evacuating the flask + vibration), the setting phase has long begun until the flask finally has its rest.

The target is to mix slurry under vacuum, to fill slurry under vacuum into the flask under vibration and to release vacuum as soon slurry is in the flask. This is only possible in a system called investment mixing apparatus.

After filling the flask: give slurry 1-hour time to become totally solid. No moving of the flask, place in on a quiet place without vibration.

Afterwards: remove rubber base.

Figure 18: Indu Mix for MC16

4.17 Determination of the powder / water partial quantities

Determining amount of powder per flask this formula is helpful:

Volume of flask in cm^3 x 1.4 = amount of powder in grams

For example flask ø 8 x 8 cm

$r^2 \times \pi \times h \times 1.6$ = amount of investment powder in g

$4^2 \times 3.14 \times 8 \times 1.4 = 570$ g

Or on flasks ø 5 x 5.5 cm

$2.5^2 \times \pi \times 5.5 \times 1.4 = 150$ g

This is gross weight; volume of cone and wax pieces must be subtracted!

To find out proper amount of water according to the instruction manual of investment material:

Ratio, given by instructions: 100:40

100:40 = 570:x

40 x 570:100 = x = 228 g water

Please take notice: More water makes investment material more permeable for gases = better form filling. If the manufacturer gives a mixing ratio 37… 39 : 100, use for filigree items 39:100, on standard items use 37:100!

Make very precise measurement, use water with exact 20 °C. Too cold or too warm water can strongly change properties of the investment material like mixing time etc.

4.18 Recommendations for flasks

For standard MC16 flasks there are some recommendations:

gypsum bonded investment powder like Goldstar XL, XXX, Kerr Satin Cast 20 etc. 100: 40 powder:water

flask size	investment powder in grams	water in ml	mixing time in min:sec
Ø 30mm x 55 mm	60	24	4:00
Ø 50mm x 55 mm	150	60	4:00
Ø 65mm x 55 mm	270	108	4:00
Ø 80mm x 55 mm	390	156	4:00
Ø 50mm x 80 mm	220	88	4:00
Ø 65mm x 80 mm	370	148	4:00
Ø 80mm x 80 mm	560	224	4:00

phosphate bonded investment powder like Goldstar Platincast, H.T.
100:35 phosphate: water

flask size	investment powder in grams	water in ml	mixing time in min:sec
Ø 30 mm x 55 mm	60	21	3:00
Ø 50 mm x 55 mm	150	52	3:00
Ø 65 mm x 55 mm	270	95	3:00
Ø 80 mm x 55 mm	390	136	3:00
Ø 50 mm x 80 mm	220	77	3:00
Ø 65 mm x 80 mm	370	130	3:00
Ø 80 mm x 80 mm	560	196	3:00

4.19 Preheating of the flasks

After investment process the flasks have to undergo a firing process. For this purpose the flasks have to be placed in the furnace with the button (opening) down to ensure a complete flow-out of wax.

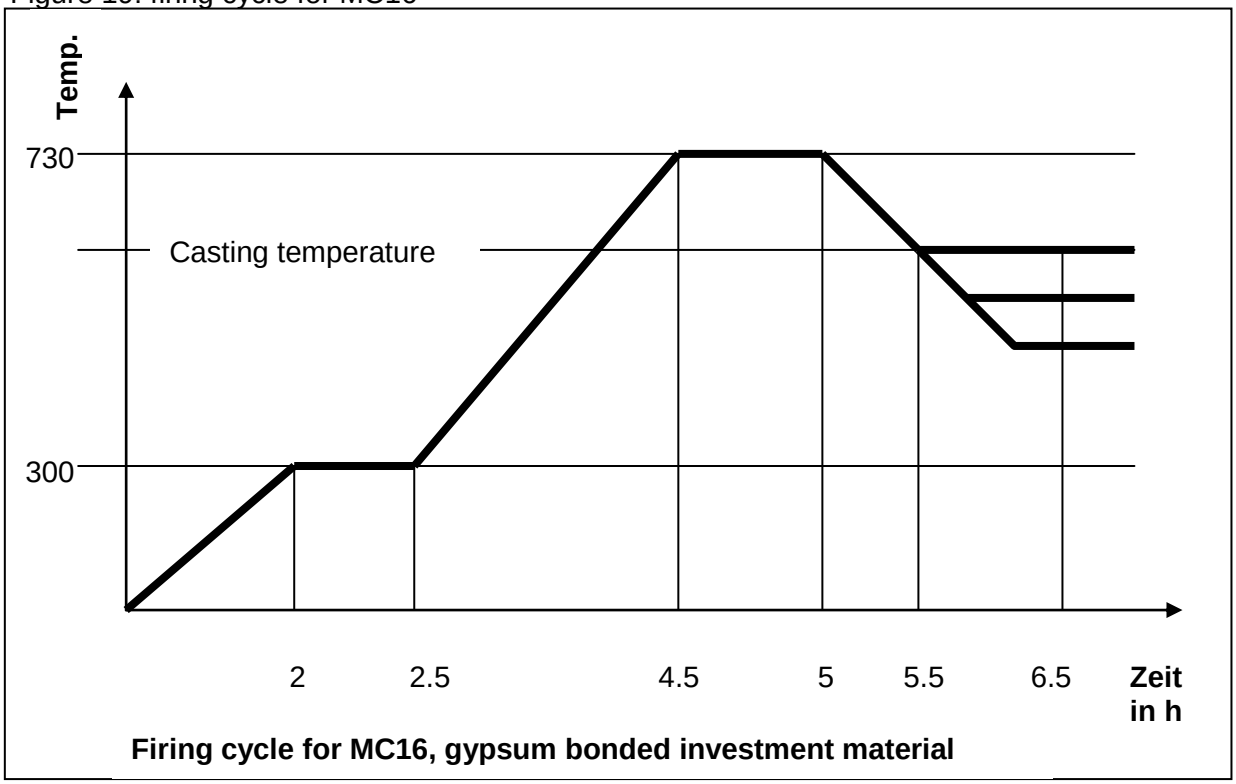
The firing cycle of gypsum bonded flasks has normally 3 phases:

- **Phase 1.** Melting out of wax and steaming out remaining moisture of flasks very slowly. This steaming out process should be done very gently to prevent gypsum against cracks. In case of the flasks for **MC16** (comparatively small) we recommend to reach a temperature of 300 °C (= ramp of 2.5 °C/min) in 120 minutes. On bigger flasks, we recommend to go to 150 °C – 180 °C in 120 minutes. Investment powder is a good insulator, that's why the heat takes time to reach the core of the flask. To ensure that the flasks heat up homogeneous, let the flasks have a rest at the hold temperature of 30 minutes on small flasks and up for 60 minutes on bigger flasks. After this time the wax should be fully flowed out.
- **Phase 2** Burning process of flasks. This process is like a sintering process: single particles bake together (bonding) and the investment material becomes much stronger. Gypsum bonded investment materials need 730 °C for this bonding process. To reach this temperature starting at 300 °C, ramp should be 4 °C/min = process takes around 2 hours. On bigger flasks (starting at 150 °C, we recommend to select ramp 5 °C/min. Duration in the furnace: for small flasks like MC16 around 1 hour, on bigger flasks up to 5 hours.

With phosphate-bonded investment you can go immediately to casting temperature. The flask can be heated up in 2 hours from 300 °C to e.g. 900 °C. (equivalent to a ramp of 5 °C/min) and keep there 30 to 60 minutes (smaller flasks less time, bigger flasks more time.

- **Phase 3** Bringing flasks to casting temperature. After reaching the casting temperature in the furnace, please give flask a rest of 30 – 60 minutes (depending on size) to ensure that set the temperature is also inside flask.

Figure 19: firing cycle for MC16

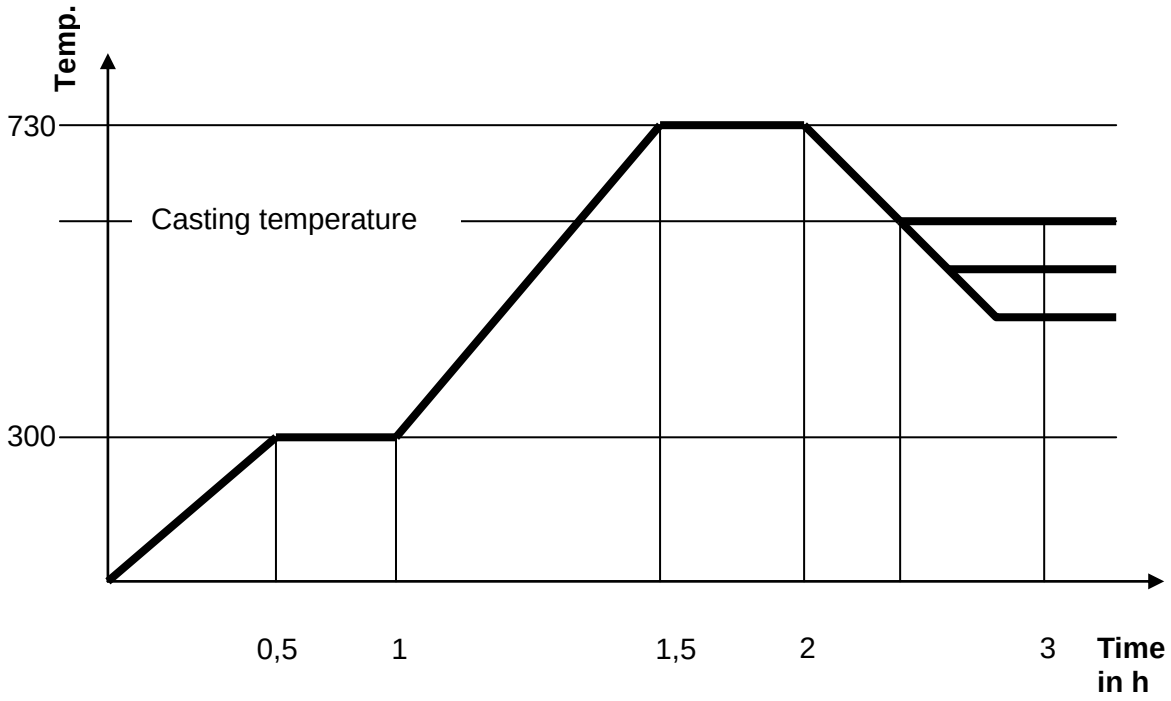


Firing cycle for MC16, gypsum bonded investment material

This “gentle” firing cycle needs maximum 7 hours, so from wax to casting it will take only one day.

But it is also possible to push this cycle. Here a recommendation of a RAPID firing cycle:

Figure 20: Rapid firing cycle



RAPID firing cycle for flasks MC16 gypsum bonded investment material

Caution: In case of a “gentle”-firing cycle all amenities of the investment material are prevented from damage. A rapid firing cycle doesn’t take care on these amenities. Already aged investment powder or thus of lower quality can react because of gruff handling with cracks.

In the dental field, most people are using “SPEED”-investment material. The fresh invested flask can be set into the HOT furnace directly. After 1-hour the flask is ready for casting. Please ask a Dental Depot about this investment material.

Standard-burnout-cycle for gipsum: (from investment to casting 6.5 hrs)
Resting time after investment 30 min,
in 2 hrs (2.5 °C/min) to 300 °C, holding time 30 min,
in 2 hrs (6 °C/min) to 730 °C, holding time 30 min (with flasks Ø 65 mm x 80 mm and Ø 80 mm x 80 mm should the holding time be extended to 60 min verlängert werden) and
in 30 min (4.3 °C/min) to 600 °C, holding time 30 min.

Rapid-cycle gipsum: (from investment to casting 3 hrs)
Resting time after investment 30 min,
in 30 min (10 °C/min) 300 °C, holding time 30 min,
in 30 min (14.3 °C/min) auf 730 °C, holding time 30 min (with flasks Ø 65mm x 80 mm and Ø 80 mm x 80 mm should the holding time be extended to 45 min) and
in 10 min (13 °C/min) to 600 °C, holding time 20 min.

Standard-burnout-cycle phosphate bonded: (from investment to casting 5 hrs)
Resting time after investment 1 hr,
in 1 hr (5 °C/min) to 300 °C, holding time 30 min,
in 2 hrs (5 °C/min) to 900 °C, holding time 30 min (with flasks Ø 65 mm x 80 mm and Ø 80 mm x 80 mm should the holding time be extended to 60 min).

Rapid-curve phosphate- bonded investment: (from investment to casting 2 hrs 15 min)
Resting time after investment 30 min, in 75 min (12 °C/min) to 900 °C, holding time 30 min (with flasks Ø 65 mm x 80 mm und Ø 80 mm x 80 mm should the holding time be extended to 60 min).

4.20 Flask temperatures

The casting temperature depends on metal alloy and style of castings.
High melting point of metal needs high flask temperatures, thin and delicate pieces with long flow ways too.
Low melting point of metal needs lower flask temperatures, heavier massive pieces too.
Ask metal supplier about their recommendation.

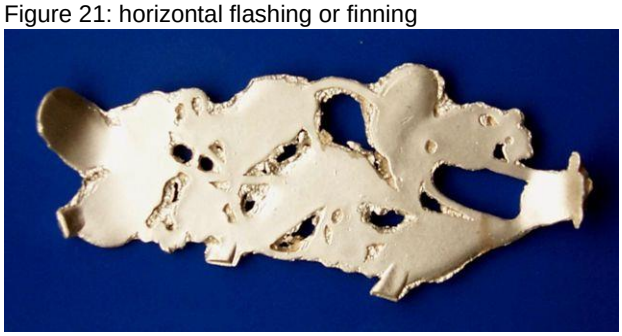
List of metals and recommended casting temperatures

		Flask temperature in °C		
Metal	**Casting temperature in °C**	Pieces thin	Pieces medium	Pieces heavy
Aluminium	720	300	250	200
Silver 925	980	650	600	400-600
Y. gold 14 kt	950	620	600	400-600
Y. gold 18 kt	1050	620	600	400-600
W. gold 18 kt	1150	620	600	400-600
W. gold 18 kt Pd	1300	650	630	400-600
Steel		900	800	700
Palladium		950	900	870
Platinum		950	900	850

4.21 Collection of spoiled castings

Horizontal flashing or finning

Figure 21: horizontal flashing or finning



Cause

- Incorrect powder / water ratio (too much water).
- Work time of investment not used up.

Remedy

- Using correct amount of water (especially important with vacuum investing machines).
- Ensuring the work time is used up and slurry temperature is 20 – 22 ºC.

Other flashing or finning

Figure 22: other flashing or finning

Cause

- Work cycle too long. Investment beginning to set while still under vacuum.
- Disturbing the flasks too soon.
- Heating too quickly during de-wax.
- Moulds allowed drying out before burning out.

Remedy

- Ensuring the work cycle is not too long and slurry temperature is 20 – 22 ºC.
- Leave the flasks for at least one hour undisturbed.
- Do not put the flasks in the hot oven. Do not exceed 150 ºC during de-waxing.
- If not burning out the same day, keep moulds wet by covering with wet sacking or plastic sheets.

Bubbles - Complete Spheres

Figure 23: bubbles - complete spheres

Cause

- Investment too thick. Too little water.
- Vacuum pump/ tank faulty.
- Work cycle too long. Investment beginning to set while still under vacuum.

Remedy

- Use correct powder / water ratio.
- Ensure equipment is regularly serviced and adequate for the task.
- Ensuring the work cycle is not too long and slurry temperature is 20 – 22 ºC. Release vacuum after full-filled flask.

Bubbles-Incomplete Spheres

Figure 24: bubbles - incomplete spheres

Cause

- Static electricity on waxes.
- Grease or dirt on waxes.

Remedy

- Use a wax wash. NOTE: THE WAX MUST BE COMPLETELY DRY BEFORE INVESTING.

Water marking

Figure 25: water marking

Cause

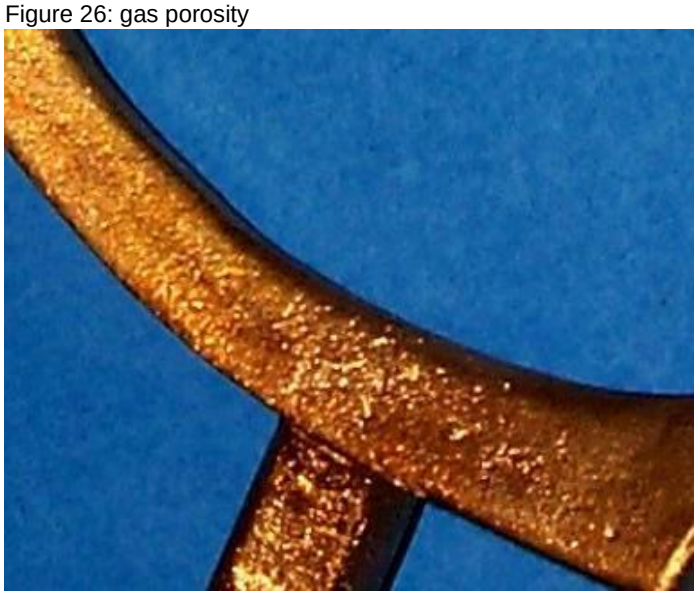
- Incorrect powder / water ratio (too much water).
- Work time of investment not used up.

Remedy

- Use correct amount of water (especially important with vacuum investing machines).
- Ensuring the work time is used up and slurry temperature is 20 – 22 ºC.

Gas porosity

Figure 26: gas porosity



Cause

- Overheating the metal.
- Inadequate burn out.
- Flask overheated during burn out.
- Impurities in the metal.

Remedy

- Reduce metal casting temperature.
- Increase the time at 730 ºC.
- Ensure maximum burn out temperature does not exceed 730 ºC.
- Do not use more than 50 % recycled alloy and ensure it is clean.

Rough Surfaces

Figure 27: rough surfaces

Cause

- Rough waxes.
- De-wax temperature too hot.
- Steam de-waxed for too long.
- De-waxed too quickly.
- Flasks overheated during burn out.
- Metal too hot.

Remedy

- Use less release agent on the rubbers. This can be caused by excess of talcum. Use only a trace of talcum. Never use silicon spray.
- Do not exceed 150 ºC during de-wax.
- Steam, de-wax for a maximum of 1 hour. Steam will erode surface of the investment.
- Leave flask for at least 1 hour to achieve maximum strength before de-waxing.
- Ensure maximum burn out temperature does not exceed 730 ºC.
- Reduce casting temperature.

Inclusions

Figure 28: inclusions

Cause

- Improper sprues.
- Crucible break down.
- Dirty metal.
- Flasks overheated during burn out.

Remedy

- Eliminate sharp corners in sprue system.
- Replace crucible. Do not used old, disintegrating crucibles.
- Do not use more than 50 % recycled alloy and ensure it is clean.
- Ensure maximum burn out temperature does not exceed 730 ºC.

Incomplete castings

Figure 29: incomplete castings

Cause	Remedy
• Metal or flask too cold.	• Please increase casting temperature. If the metal or mould is too cold, the metal will freeze before completely filling the mould.
• Improperly sprue.	• The sprue system should be designed to allow the metal to enter easily and without restriction.
• Incomplete burn out.	• Increase the burn out time at 730 ºC. If the flask is not properly burnt out it will be impermeable and not allow gases to escape when the metal enters the mould.

Shrinkage porosity

Figure 30: shrinkage porosity

Cause	Remedy
• Incorrect sprue.	• Sprues should be attached to the heaviest piece of the casting. There should be sufficient sprues to ensure the casting is adequately fed.
• Flask temperature too low and sprue is incorrect.	• The flask temperature should be just hot enough to achieve complete fill, according to the mass of the casting material.

Blisters, spalling

Figure 31: blisters, spalling

Cause

- Flask has been heated too rapidly during de-wax.
- Flasks overheated during burn out.
- Flasks put in furnace too soon after investing.

Remedy

- Do not exceed 150 ºC during de-wax. Wax will boil and erode investment surface.
- Ensure maximum burn out temperature does not exceed 730 ºC.
- Leave flasks undisturbed for a minimum of one hour before de-wax.

5 Transport

Danger!

Injuries because wrong transport.

- Take care of the right position using transport device to avoid tilting of the system.
- Please wear appropriate personal protective equipment (PPE).
- Let do transportation only by trained personnel.

There is no guarantee for damages because of failure to comply transport regulations.

> Transport the system upright. If the machine is transported in another position, the system will be damaged.

6 Mounting and commissioning

6.1 Safety advices for mounting

Danger!

Only experts may work at the electrical equipment.

Danger!

Observe the mains supply to requirements of the local electricty supply company, the VDE and the local electricity company.

Use always the 2-pin power plug with safety contacts for connecting the system to the mains supply. Improper connection can result in injury and damage to the system.

Danger!

Check before connecting the system, whether the existing mains voltage corresponds with the operating voltage of the system. If the voltages do not match, the system can be damaged.

6.2 Mounting process

Place the system on a clean and dry table horizontal. The ground must be firm and level. Around the machine the following work area must be kept free: left and right 0.5 m. Behind the machine 0.5 m. Before the installation at least 1.5 m of free workspace.

Cooling air may not exceed 35 °C (95 °F) and should be free of contaminations.

Establish supply connections according to the information in chapter 3 „Technical Data”:

- current,
- protective gas,
- cooling water and
- vacuum.

Examine supply lines and connections for damages.

Only after the correct connection of all supply and connecting systems, the system may be put into operation.

6.3 Apply supply connections

6.3.1 Power supply

The electrical connection may only be performed by a specialist. Note the information specified on the nameplate rated voltage or frequency. The single-phase power supply may differ for max. +/- 10% from the rated voltage.
The mains supply must be equipped with a 16 A fuse (slow). The system is supplied with A power plug with earthing contacts is supplied with this machine. All three lines (L, N and PE) must be connected correctly.

The wall socket of the mini-casting unit MC16 must be freely accessible.

On the installation site must be provided by a loop impedance measurement of the detection of the switch-off of the overcurrent protective device.

High leakage current:

This machine has a leakage current of 4.45 mA.

Please take notice: The machine must have own mains line. It is not allowed to use the machine at the same fuse as the burnout furnace!

6.3.2 Cooling water

Cooling water supply is connected to machine by 2 hoses with outside diameter of 6 mm.

Water pressure must be 2.5 bar at minimum and don't exceed 5 bar. Water outlet must be pressureless.

Input water temperature should be between 15 °C (59 °F) and 25 °C (77 °F).

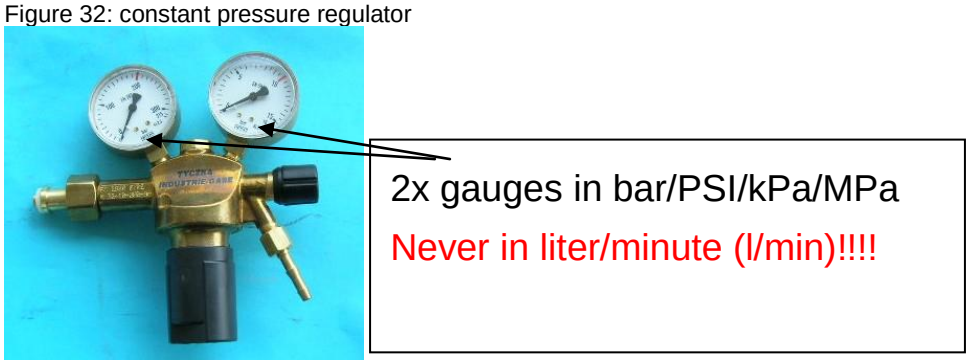
Lime concentration may not exceed of maximum 6 German hardness degrees. The water should be free of pollutions.

Attention:
The cooling water flows continuously even when the mains switch is switched off!

6.3.3 Protective gas

The protective gas only nitrogen or argon may be used with a purity status of at least 99.9 %. The supply is effected via a compressed air hose having an inner diameter of 6 mm. The inlet pressure must not exceed 8 bar. Gas consumption is about 1 - 3 l/min. Please use only a constant pressure regulator.

Figure 32: constant pressure regulator



6.3.4 Vacuum

Here, a vacuum pump with a suction capacity of at least 8 m³/h and a final pressure of 2 mbar should be connected via a tube of 8 mm in outside diameter. Keep the tube short to avoid vacuum loss. The pump should run 5 minutes **before and after** the casting to bring the pump at working temperature and evaporate moisture in the end.

For detailed information, please also refer to the operating manual in maintenance of the vacuum pump.

6.3.5 Gas out

Exit to the pressure reduction. This output must be kept clear at all times. You can connect a hose to lead fumes to the outside.

Figure 33: Check of the backside connections

6.3.6 RS232 for service

At this plug behind a black cover our modem (item no. 71000320) or our serial cable (50500060) can be connected for service issues.

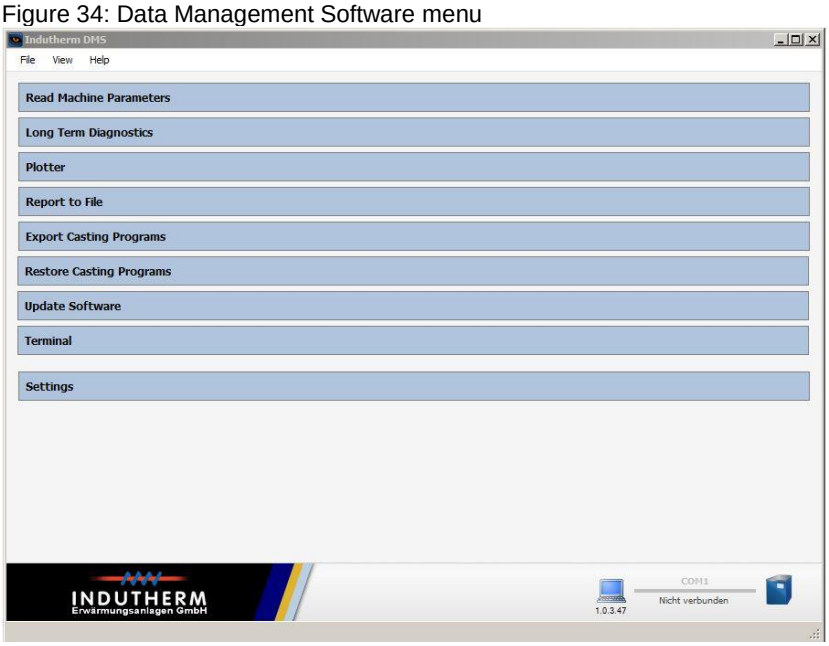
6.3.7 LAN, Ethernet or RJ-45 connector for service

Behind a black cover, you'll find this plug to connect the machine to a network (LAN-local area network). You can collect and store machine data with help of our data-management-software (DMS).

6.3.8 USB-socket (B-type) for service

Behind a black cover, you'll find USB (universal serial bus)-plug for connection with PC. With help of DMS you can read out system-data and casting programs for service questions.

Figure 34: Data Management Software menu



7 Operation

7.1 Safety advices for operation

Caution!

Examine all consumables, insulations and hoses before switching on. Check for damages and cleanliness, especially crucible and glass shield. Operate the system only when it's free of damages.

Warning!

Risk of burning on hot surfaces and hot metal (until ~ 2000 °C). Wear always personal protective equipment when you work with the machine.

Utmost caution during using graphite crucibles and graphite moulds. The heat of these parts is only visible when the temperatures are over 500 °C.

Danger!

Risk of burns. If metal is melted without the supply of protective gas, can cause a flash fire or explosion when opening the bell.
Melt at temperatures above 500 °C always with protective gas. Use as a protective gas exclusively argon or nitrogen.

Attention!

At crucible temperatures over 100 °C the cooling water supply must be switched on. If it is not turned on, the inductor will be destroyed. If cooling water supply fails, the heating system immediately is turned off. Inspect the system for damage before putting back into operation again.

7.2 Changing casting parts

Attention!
Switch off the machine at mains switch, when you change consumables, like e.g. crucible.

7.2.1 Removal

> Open the top plate of the casting chamber.

> Remove “old crucible”. Check glass inductor shield.

7.2.2 Mounting

> Check crucible surface for damages and cleanliness before you start casting.

> Put a small piece of quartz fleece in glass inductor shield.

Figure 35: quartz fleece in inductor shield

The crucible should be sitting easily on the quartz fleece. The crucible collar should be close to the glass inductor shield.

Figure 36: crucible and glass inductor shield

Place crucible with glass inductor shield in the induction coil.

7.3 Recommendation for a casting process

Figure 37: further suggestions of casting programs

Suggestions		
Material		**Yellow gold 14k**
Crucible		Graphite
Temperature reading		Thermo-couple
Program No.		
Temperature	°C	1080
Heating power	%	0050
Washing before heating		0000
Washing while heating		0001
Melting pressure start		Manual
Melting pressure	bar	-0.80
Casting pressure	bar	2.00
Label		585/YG

> Switch on water-, protective gas and vacuum supply.

> Prepare crucible with thermocouple. Switch on mains switch (booting takes about 10 seconds).

> Fill in casting material.

> Put in preheated flask (620...650 °C).

> Close and lock casting chamber secure.

Figure 38: safe handling of lock

Close the lock with the ball of hand. Hold the hand open and use a glove.

> Start your casting program with “Start” button.

> If casting temperature is reached press “Start”-button again for building up vacuum (melting pressure).

> After 10 seconds please press the button on the handle and tilt the chamber uninterrupted clockwise til the catch. Release the button on the handle to lock the unit in the tilted position. During the tilting the unit automatically switches from vacuum (melting

pressure) to overpressure (casting pressure) inside the chamber. The generator stops heating. On the display “Time” a timer counts the seconds after casting.

> After a sufficient waiting time, unlock the handle and tilt the unit back to horizontal position. The casting pressure inside the crucible chamber is released through “Gas Out” to ambient pressure.

> Open the casting chamber and remove flask and flask holder.

Attention!

You have to activate the melting pressure by pressing “Start”-button after the washing cycles.

7.4 Error diagnosis

There two types of trouble.

- Error and
- Warnings.

If an error occur the heating will be switched off and you’ll see error code in display.
With a light fault a warning appear in display. You’ll see the warning code in display.

7.5 Troubleshooting

Only an expert may open the system.

Trouble	Cause
Machine can’t be switched on.	• Missing mains supply.
Heating don’t work	• Missing water supply ‘E010’. • Missing protective gas supply ‘E083’. • Thermocouple not connected or defect ‘E041’. • Generator overheated (too hot), ‘E021’. • Other error, error display ‘Exxx’. • Exhibition mode activated (P.155 = 0?!).
Temperature indication not right	• Wrong thermocouple programmed, see software documentation. • Thermocouple faulty. Because of that the generator can stop heating!
Low generatoroutput	• Set-value of temperature too low.

Additional error messages see software-documentation.

7.6 Service

If you need technical support from company INDUTHERM Erwärmungsanlagen GmbH, we’d like to have following information with first contact:

- Service No. M19999 on the left front side of machine or
- Service No. from nameplate at backside of machine.

8 Maintenance

8.1 Safety advices for repair and maintenance

For reliable use and highest work accuracy use is regular maintenance and service of your system a prerequisite. The necessary working steps are summarized in this chapter and have to carry out in time.

Warning!

Perform maintenance and repair work on the system only if the system has been disconnected from the power supply (pull the plug).

Danger!

Danger of death from touching electrical parts.

Work on electrical equipment may only be performed by authorized personnel.

Access to the electrical installation room is allowed only for authorized personnel with a tool.

Work on the electrical equipment may only be carried out when the system has been disconnected from the power supply (pull the plug).

- The capacitors may still be charged even after turning off the system.
- The cabinet of the mini casting machine must be kept close always.

- No work carried out on energizes parts.
- Eliminate loose connections.
  Replace damaged, scorched or burned cables immediately. Perform work only when the mains plug is out.
- Cables must not be clamped or pinched. Cables must be routed so that they do not form a tripping hazard or be damaged.

Danger!

Risk of health problems due to exposure to medium from damaged hoses. Risk of damage to the system.

- Eliminate loose connections. Replace damaged hoses immediately. Maintain only when the mains plug is out.
- Hoses must not be clamped or pinched. Hoses must be routed so that they do not form a tripping hazard or be damaged.

Warning!

Risk of injury.
Make pressurized plant parts at zero pressure before works is carried out there.

Warning!

Slipping on the floor in the area around the plant, if lubricants or solvents were spilled.
Clean the dirty floor immediately! Discard the cleaning cloths in the collecting means made available.

8.2 Maintenance schedule

Follow the maintenance schedule to obtain the functionality of the system.

Daily (before casting)

Warning!

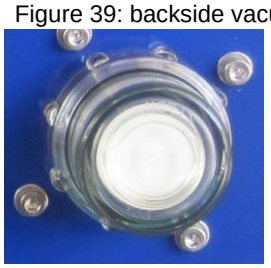
Burning hazard because of leaking melted metal.

- Remove thermocouple, crucible and crucible shield. Clean inductor housing carefully with a vacuum cleaner. Check components before installing and replace them if necessary.

Please take care of oil quality from vacuum pump: If the oil is cloudy or milky do a “decontamination” of the pump. Study the pump manual.

Check the backside vacuum filter with compressed air. Don’t blow the dust in the room and wear a dust mask. When the filter is clogged takes it longer time for vacuum level of -1.00 bar and warning E081 will appear.

Figure 39: backside vacuumfilter



Every year

- Cooling water system with about 25 % citric acid rinse for about an hour. Then system thoroughly flush with clean water and check for possible leaks. This cleaning-supply cycle is highly dependent on the hardness and cleanliness of the cooling water.
- Tighten all electrical connections, especially the high current connections.
- Retighten all screws of the water cooling, compressed air and protective gas supply.

Every 4 years

- Repeat electrical test of the device.

  The intervals of 4 years relate to a trouble-free operation of the electrical equipment. After an exchange of components (repair or extension) are in
  EN60204-1: 2006 + A1: 2009
  defined tests to be performed.

Note:

The operator is in accordance with the Industrial Safety Regulation (BetrSichV) in Germany or pursuant to Directive 2009/104 / EC * in the EU required to define the cycle for the safety inspection of mechanical and electrical equipment.

8.3 Repair

The system must be repaired only by authorized personnel. Never try to repair the system yourself. Incorrect repairs can lead to health problems or damage to the equipment.

*Directive 2009/104/EG

of the European Parliament and of the Council of 16 September 2009 concerning minimum safety and health protection for the use of work equipment by workers at work (second individual Directive within the meaning of Article 16 paragraph 1 of Directive 89/391 / EEC).

9 Dismantling and cleaning up

Warning!

Permanent skin damages after touching lubricant or solvent of every description (long term effects).

- Avoid touching lubricants, solvents and coolants.
- Wash the sprinkled skin parts thoroughly.
- Wear protective gauntlets when using lubricants, solvents and coolants.

Attention!

Disposal of possibly applied lubricants and harmful cleaning agents is strictly regulated by the Environmental Protection Act and its regulations.

- Deliver applied lubricants at the hazardous waste collection point.
- Spilled lubricants must immediately sprinkle with binder and dispose them after binding as hazardous waste.
- Provide all materials to collect spilled materials (sealed bottom, catch basins, collecting tarpaulins).

> Separate the system off the mains supply and other supply connections.

> Depressurize all system parts which can be under pressure.

> Dispose the system with the help of an appropriate lifting gear.

> Clean the parts of the system.

> Follow legal regulations at handling and cleaning up of old system parts.

> Bring metal pieces to the recycling.

10 Annexe

10.1 List of figures

10.2 CE Declaration of conformity

Manufacturer:	INDUTHERM Erwärmungsanlagen GmbH Brettener Str. 32, 75054 Walzbachtal, Germany
Product type:	Mini-casting machine
Machine type:	MC16
Serial number:	16265 or higher
Authorized to sign:	Peter Hofmann

We herewith declare that the machine named above corresponds to the essential safety and health requirements of the following EC directives because of its design and construction in the version which we have placed on the market.

Legal normative basis

Machinery Directive 2006/42/EG (MRL) in extracts Reference - Directive 2006/42 / EC, EU-Ab. No L 157/24 of 9 June 2006
EN 60204-1:2006+A1:2009 Security of machines Electrical equipment of machines Part 1 General requirements
EN 61010-1:2010 (in extracts) Safety requirements for electrical equipment for measurement, control and laboratory use Part 1: General requirements
EN ISO 12100:2010 Safety of machinery General principles for design Risk assessment and risk reduction
EN 349:1993+A1:2008 Safety of machinery Minimum gaps to avoid crushing of parts of the human body
EN ISO 13849-1:2015 Safety of machinery Safety-related parts of control systems Part 1: General principles of design
EN ISO 13849-2:2012 Safety of machinery Safety-related parts of control systems Part 2: Validation

EN ISO 13850:2008 Safety of machinery Emergency stop function – Principles of design
EN ISO 13857:2008 Safety of machinery Safety distances to prevent hazard zones being reached by upper and lower limbs
EN ISO 14120:2015 Safety of machinery Guards – General requirements for the design and construction of fixed and moveable guards
EN 1037:1995+A1:2008 Safety of machinery Prevention of unexpected start-up
EN ISO 11201:2010 Acoustics Noise emitted by machinery and equipment – Determination of emission sound pressure levels at a work station and at other specified positions in an essentially free field over a reflecting plane with negligible environmental corrections.

EC Directive on Electromagnetic Compatibility Reference - Directive 2014/30 / EU, EU-Ab. No L 96/79, 29 March 2014
EN 61000-6-2:2005 Electromagnetic compatibility (EMC) Part 6-2: Generic standards - Immunity for industrial environments
EN 61000-6-4:2007+A1:2011 Electromagnetic compatibility (EMC) Part 6-4: Generic standards - Emission standard for industrial environments

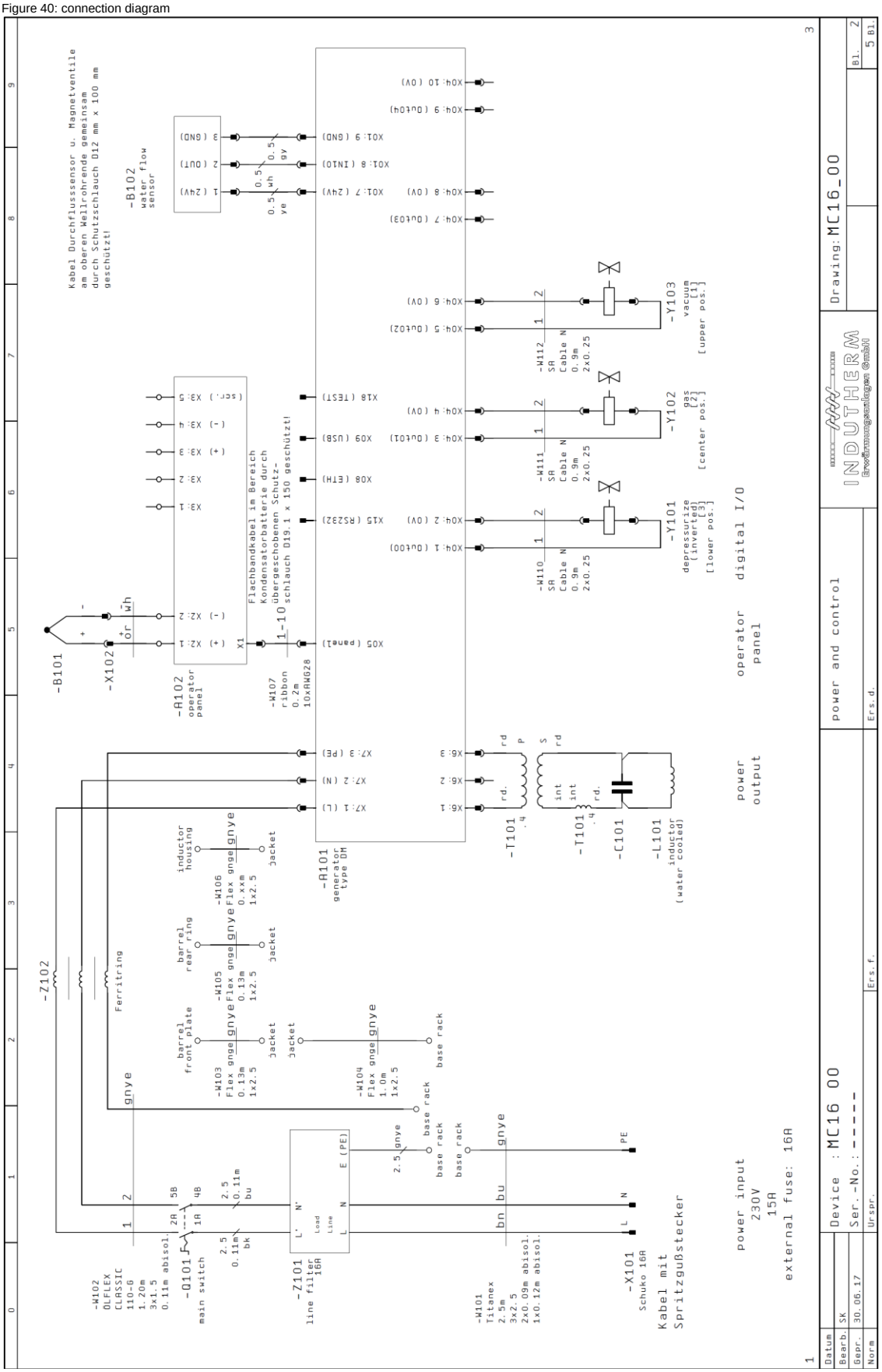
The declaration of conformity relates only to the machine in the state in which it was placed on the market; Parts and / or retrospective interventions carried out subsequently by the end user remain unaffected.

The test protocols are stored at INDUTHERM for 10 years.

city/date/signatory: Walzbachtal/2019-10-16/Peter Hofmann, chairman

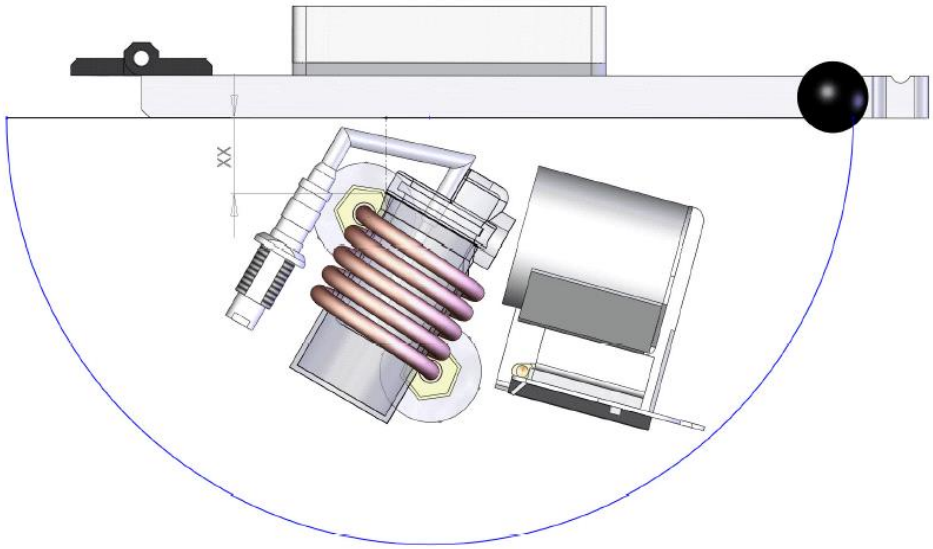
10.3 Connection diagrams

Figure 40: connection diagram



10.4 Cut diagram of the replacement parts

Figure 41: inductor chamber



10.5 Consumable – and spare parts list

INDUTHERM is now using only machine specific spare parts list, which contain all the information for your machine.

At following page, the spare parts list for this machine will start.

The item number of the consumables list is composed by following parts:

1.) G (for starter kit/basic equipment)

2.) The next five digits are the machine service number.

3.) The following combination of letters describe the application (please read further below).

4.) The last two digits are the actual state, starting with '_00'.

One example: G19999_MC_00. This is the consumables list of machine no. 19999, equipped as mini casting machine with delivery index '00'.

At request we can send you the actual consumables list in PDF-format. Is there a consumable part or replacement piece replaced by an advanced or better one, change the index number in the end of item no. in ascending order, in this case to G19999_VC_01? This list replaces the previous edition with index ‚_00'. This should lead to the situation you have always access at the actual consumable and replacement parts of your machine.

For ordering of replacement and consumable parts please contact your dealer or at our order service with

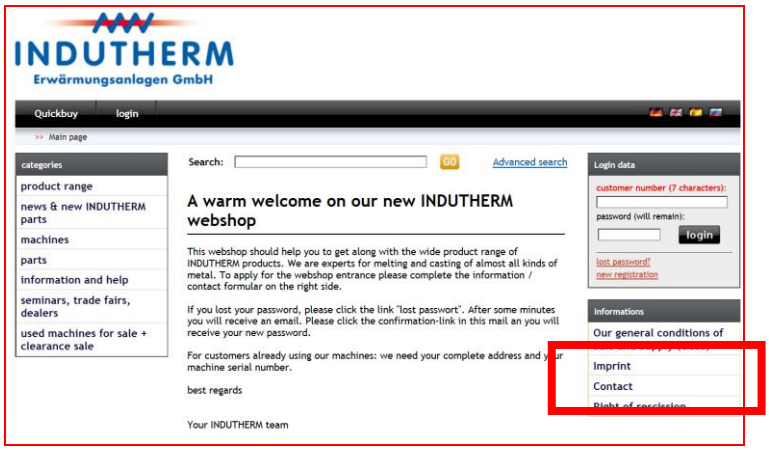
telephone number: +49-(0)-7203-9218-40.

10.6 Software documentation with error messages

Software-Documentation starts at next pages. The label of the bilingual documentation is “generator_documentation_80000xxx_customer_DM_F_PM_Gen.pdf”. xxx is the software state. This is also valid for 801.00xxx software in your machine since 2018.

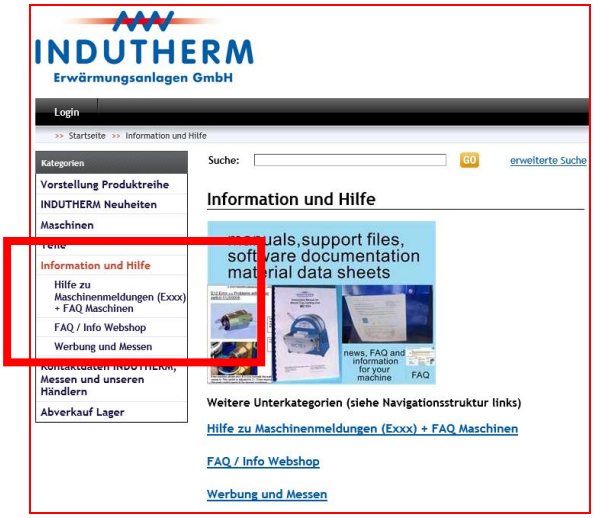
Please note: At our Internetpage http://www.indutherm.de/webshop you can get after registration access to important data.

Figure 42: contact form webshop



Until you can enjoy the advantages of the Webshop you have to apply for an access. Therefore please fill in the form of contact and send it to us. With mentioning the machine number you’ll get full access to webshop content.

Figure 43: Webshop help with machine messages



Then we will send you the access codes. You’ll find explaining documents in the subdirectory “help with machine messages”.