INDUTHERM
CASTING TECHNOLOGY MADE IN GERMANY

Opperation Manual

Granulating Machines

GU 500 / GU 500 micro

revision			
date	**chapter**	**reason**	**responsible**
2013-07-22	all	new edition	Schmidt
2017-12-11	all	Edition 2017	RK
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2020-03-23	7	chapter Micro-granulation	JF, RK
2026-01-22	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

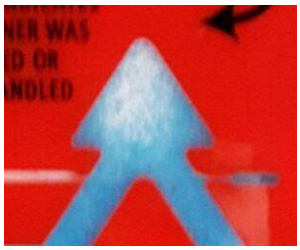
The granulating machine GU500/GU500 micro is delivered complete. Please check delivery immediately after receiving the shipment if there is something missing or possible transport damages. Please tell the faults the shipping agency and your dealer.

Information!

There are two tilt sensors. One is on the transport box. Check the outdoor sensor as long as the transport company is there. A sensor is in the machine.

Figure 1: Sensor #84400010

If the machine was tilted.



1.2 Liability, warranty and guarantee

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

The granulating 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 Indutherm.

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 granulating machine is only guaranteed at intended use.

The granulating machine serves exclusively for melting, pouring and vacuum casting of commercially available precious metals and of copper- or aluminium-alloys. 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!

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 granulating machine must not be placed in areas with explosive atmospheres.

The granulating machine is not intended to melt medically or biologically contaminated components.

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.

When operating the system escape gases / vapours. These are consumable parts dependent applications you use and the molten material. The plant operator must provide a suitable on site and the current standards and laws appropriate exhaust system.

The lightning protection and the measures for overvoltage protection must be ensured on site.

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 main-switch with emergency stop function,
- safety switch that is used to ensure that the plant can be operated only with the swivelled granulating tank;
- 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

Personal protective equipment (PPE)
Protective clothing: **EN ISO 11612:** Clothing to protect against heat and flame
Use protective gloves against finger/hand risks according to the following standards: **EN 388:** Protective gloves against mechanical risks **EN 407:** Protective gloves against thermal risks **EN ISO 374:** Protective gloves against chemicals
Safety glasses / visors: **EN 166:** Personal eye protection
Ear protection: **EN 352-1:** Hearing protectors – Earmuffs **EN 352-2:** Hearing protectors – Earplugs
Safety footwear **EN ISO 20345:** Personal protective equipment – Safety footwear

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 with locked main-switch. 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 Main switch with emergency stop function

It is allowed to start the machine or operation only with proper emergency stop function.

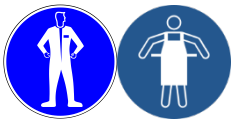
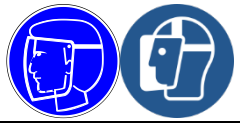
Caution!
With the emergency stop function you can stop the machine in critical moments of health hazard. You help to diminish potential consequences of injury.

> Don't manipulate the emergency stop equipment.

> Don't obstruct the way to the emergency stop equipment.

2.3.5 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.
On the front of 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
	Warning of hand injuries.		wear protective shoes
			read manual

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 is 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. For example, can with aluminium happen an explosion of hydrogen gas during hydrolysis.

Warning!

Risk of burning on hot surfaces and hot metal (until ~ 1600 °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 power plug).

- The capacitors can retain their charge even after deactivation of the system.
- Keep housing of the granulating machine 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.

Danger!

Burning risk by leaking hot metal at protective gas failure.
When protective gas failure of the sealing rod can no longer close properly. Through a check valve, the pressure is maintained in the lock cylinder.
Press after a protective gas failure, no pneumatic units (e.g.: cylinder).

Warning!

Risk of burns:

- burns because of squirting liquid metal,
- burns at hot surfaces (important here: like new insulations).

Warning!

Danger of explosion.

Dripping liquid metal can’t be excluded.

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.

Warning!

Burning hazard because of leaking molten metal.
The system must not be operated without a sealing rod for security reasons.
The tip of the sealing rod must stay in the centre of the pouring hole even when sealing-rod is open.
With built-in and closed sealing rod the according cylinder must have a gap to the lower end stop or the pouring hole is no longer proper sealed.

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. The system must be lifted from the side only, because the centre of gravity is located in front and towards the upper third of the machine.
- 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!

Health risk because of lifting heavy weight.

Lift and transport the granulating tank only by two persons. Don't try to transport the tank by yourself. There is danger of permanently healthy damages because of physical overload.

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 particular 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 crucible shield and insulation in dustproof package.
- Remove the material just before installation.
- Don't shatter crucible shield and insulation.
- 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 situation

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

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

3 Technical data

	GU500	GU500micro
crucible volume (1) in cm³	245 cm³ ~ 3.5 kg Au 18 kt	
highest working temperature in °C (2)	1600	
power in kW	10	
Operating frequency in kHz	7	
pressure area in melting chamber in bar	-1 to 0.5	
Maximum working temperature	Depending on the thermocouple used: Type N (NiCrSi-NiSi; max. 1300 °C) or Type S (PtRh-Pt; max. 1500 °C) (2)	
mains	3 x 400 V, 50 or 60 Hz 3 x 208 V, 50 or 60 Hz (option)	
fuse protection in A	16 A (400 V)(25-32 A (230 V)	
short circuit current	max. 5.0 kA	
cooling water supply	1x Ø 13 mm (until 2018: 8 mm), 2.5 - 5 bar, mind. 120 l/h, 3 to 8 °dH, PH value 7-8.5.	
water output	1x Ø 13 mm, pressurelesss, maximal 70 °C (158 °F)	
cooling water input temperature	15 – 25 °C / 59 – 77 °F {to prevent condensation: 20 - 25 °C / 68 – 77 °F}	
recommendation for water cooler	5 kW cooling capacity (50 % of heating power of GU500 e.g. TAE evo tech 020 8 kW)	
ambient temperature	10 – 35 °C / 50 – 95 °F	
relative humidity in %	20 – 80	
protective gas supply	1 x Ø 6 mm, fitting with 1/4” thread 8 bar, pure N_2 or pure Ar, with constant pressure regulator; consumption 4-6 l//min	
vacuum	1x Ø 13 mm, fitting with 1/4“ thread 0 - 20 mbar absolute, min. 21 m³/h	
Vacuum pump connection	16 A, CEE, 4 pin, maximum 1,0 kVA	
weight in kg	ca. 160	
IP Code International Protection Marking	IP20	
dimensions in mm (Wide x Depth x Height)	500 x 850 x 1550	
Options	• feeding system • window for opening • - Optical, acoustic signal when errors/warnings occur • 3bar (Factory setting only)	
noise emission dB (A)	75	

(1) These are standard values which can be optionally changed.
(2) in a special configuration

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 and mains filter,
- microprocessor controlled induction generator F-type,
- middle-frequency transformer,
- oscillating circuit capacities,
- pneumatic (magnet-) valves and
- pressure regulator for pressure of the sealing rod cylinder.

The front plate contains:

- front panel for control of the granulating process.

To the melting system belongs:

- inductor housing, water cooled with inductor, crucible, insulations, sealing rod unit, thermocouple,
- bell hinged, water-cooled and
- granulating tank.

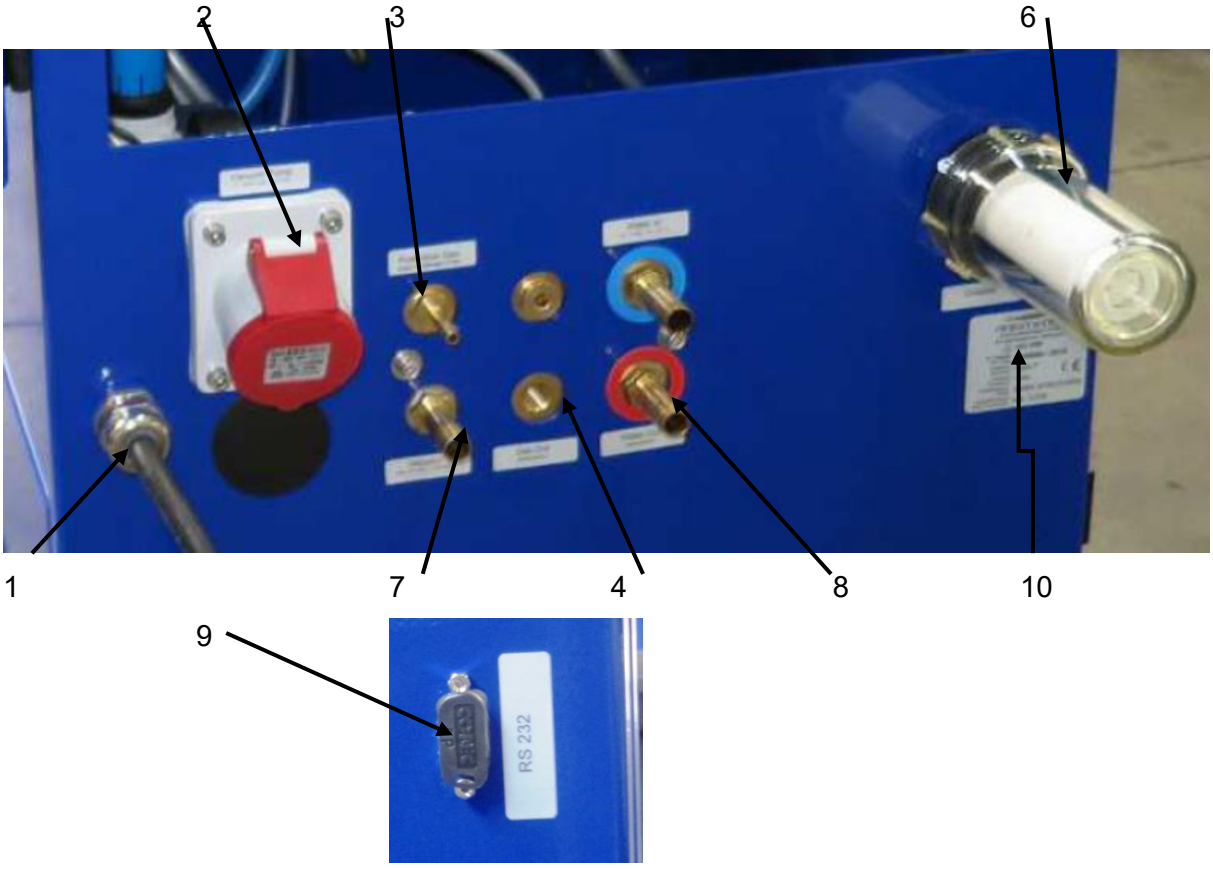
4.2 Schematic representation

Figure 2: overall view

pos.	designation	function
1	bell with window	Closing the inductor housing.
2	inductor housing (crucible chamber)	In the inductor housing are: • Induction coil • crucible • insulation
3	granulation tank	With water inlet and outlet connectors.
4	lift for granulation tank	Enables lifting of tank.
5	front panel	Control the process of the system.
6	vacuum press plate	Pressure plate for generating vacuum and overpressure.
7	safety bucket	Safety bucket for dripping material.
8	mains switch with emergency stop function	Switch on and off granulating machine.

4.3 Backside connections

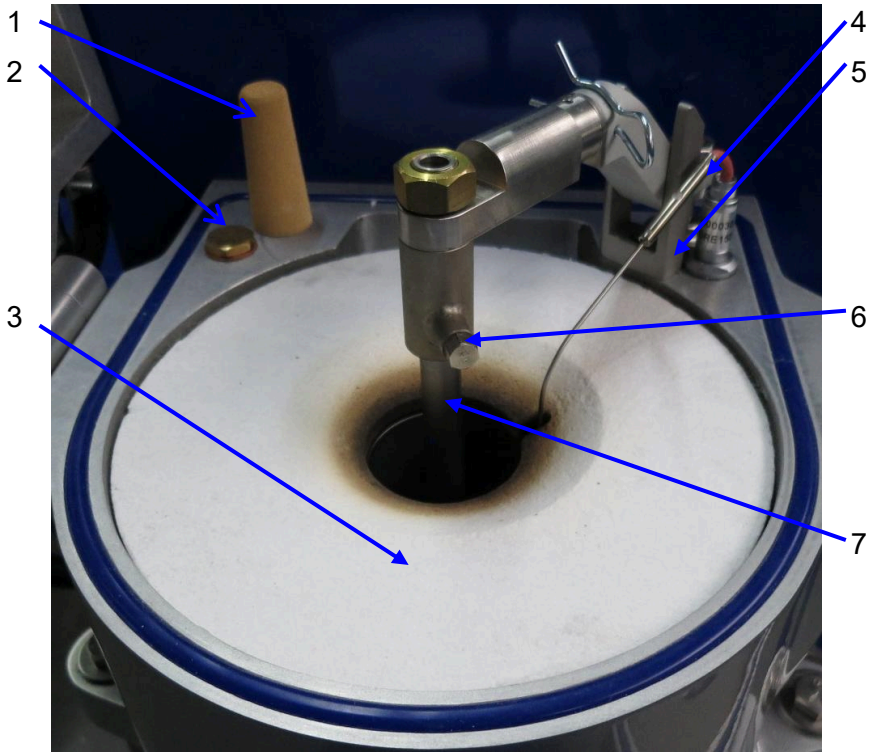
Figure 3: backside connections



position	designation	function
1	power plate	mains for the granulating system
2	vacuum pump	power supply for the vacuum pump, pump can be turned on with button at front panel
3	protective gas	protective gas input
4	gas out	depressurization
5	water input	cooling water inlet (for 13 mm hose; before 2018: 8 mm)
6	filter crucible	filter for crucible area
7	vacuum	for the hose from the external vacuum pump
8	water output	cooling water outlet (for 13 mm hose; before 2018: 8 mm)
9	RS 232	serial interface / connection for PC
	Nameplate	Important machine information

4.4 Structure of the crucible chamber

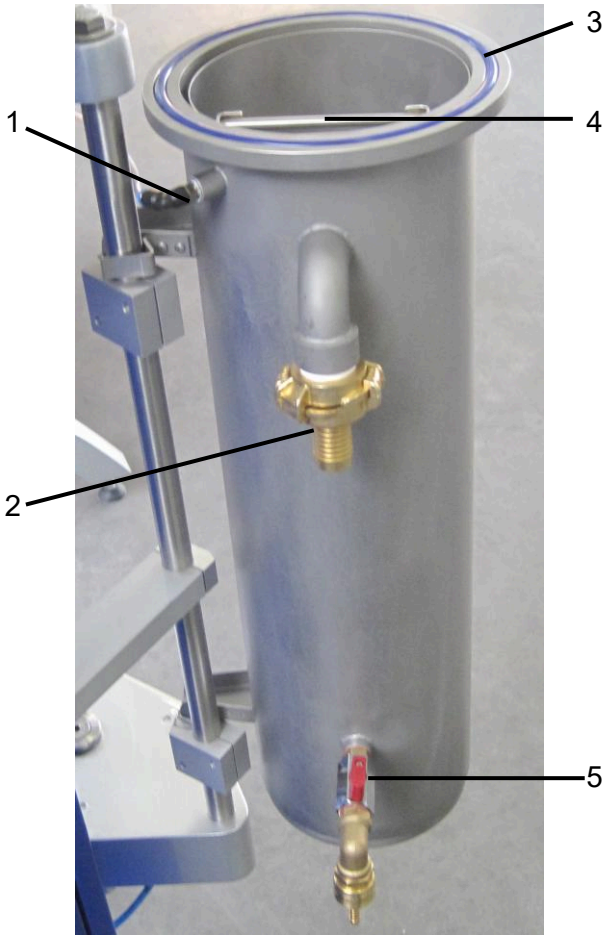
Figure 4: Structure of the crucible chamber



Position	Name	Function
1	Metal filter C038	Brass filter through which the vacuum is drawn from the crucible chamber.
2	Thermocouple connection	Thermocouple connection for measuring the wall when working with additional centre measurement.
3	Filling cone	Upper insulation and additional filling aid.
4	Thermocouple Wall	Thermocouple for measuring the wall temperature.
5	Guide	Guides the locking rod holder and secures it against rotation.
6	Locking screw	Attachment point for the 8mm socket spanner to rub the hot locking rod into the crucible hole.
7	Sealing rod	For closing the crucible hole.

4.5 granulating tank

Figure 5: granulation tank



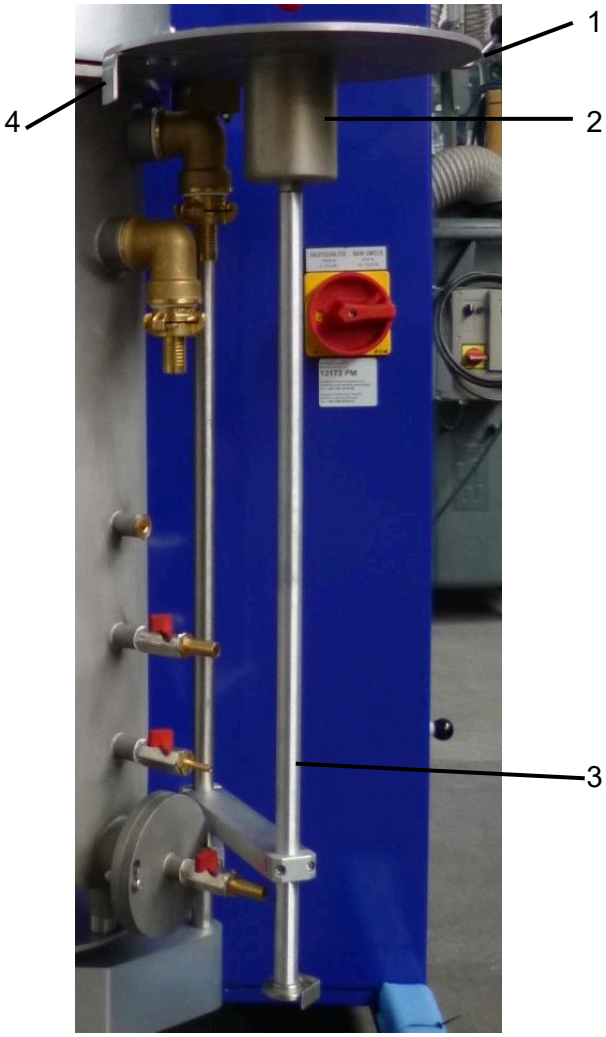
position	designation	function
1	protective gas entry	Here you can supply additional protective gas.
2	water outlet	Usual water outlet.
3	O-Ring	For sealing of the barrel without a gap.
4	Inside barrel with lever	Removable inside barrel with fast emptying function.
5	fresh water input	Control the fresh water input.

Figure 6: example of second cooling system

2-5 % content of Ethanol is recommended if risk analysis about your metal composition don't contradicts.

4.6 Contact pressure plate

Figure 7: contact pressure plate

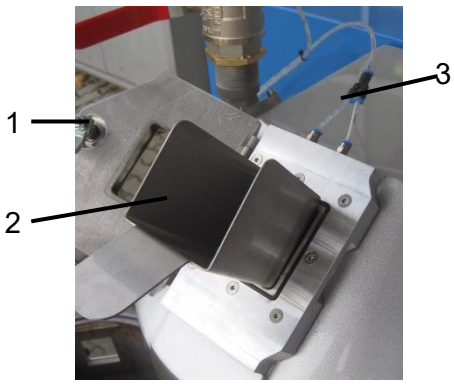


position	designation	function
1	contact pressure plate	Contact pressure plate for generating vacuum and overpressure.
2	collecting cup	Collecting cup if the crucible is leaking and for cleaning crucible after granulating with tweezers.
3	rod	Rod for extension of cylinder.
4	end stop	end stop for locking

4.7 Special options

4.7.1 Hinged window (optional)

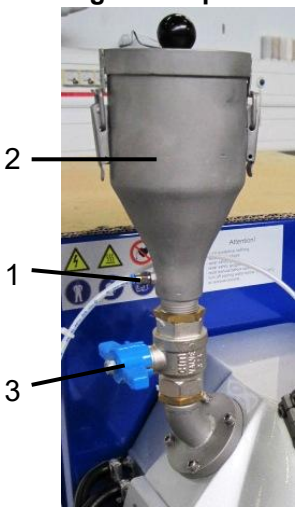
Figure 8: option vacuum sealed hinged window



position	designation	function
1	locking lever	lock the window
2	slide	for refilling the crucible
3	protective gas supply	reducing the glass from fogging

4.7.2 Refill system (optional) 71110901

Figure 9: option refill system



position	designation	function
1	protective gas	Protective gas supply for option feeding system.
2	refill container	Here the additional material can be filled.
3	lever	Open access to the refill system. Additional material can be refilled in the crucible via a chute.

4.8 Functional Description

With the granulating unit particles / grains of almost the same size can be produced from precious metals or aluminum alloys. The Latin word granum means "grain" or "grain". For this purpose, the melted material is first melted inductively in a protective gas atmosphere or under vacuum and then poured into cold water in a thin stream with constant circulation of the water. In other words: the molten metal drips from the crucible into the granulation tank and solidifies there to form granulate.

Gold ingots, sheet metal or cast residues can be used as starting forms. The main applications are:

- the preparation of alloys made of gold and a main alloy,
- the processing of alloys from components and
- cleaning metal that has already been cast.

The granulating containers are very easy to remove.

The DDP system ensures a constant and controllable metal mass flow, and thus the ratio of gas to metal regardless of the melt in the crucible. The abbreviation DDP stands for "Dynamic Differential Pressure".

The particular advantage of inductive heating is that the melting temperature is reached quickly, since the heat is generated directly in the melting material and in the crucible. Likewise, the metal is thoroughly mixed by the magnetic field during the melting process, so that homogeneous metal mixing is achieved even with new alloys.

The temperature is measured precisely by the built-in thermocouples and the output of the device is controlled so that the set temperature is kept constant.

The micro variant is used for ultra-fine granules with a grain size between 0.1 and 1 mm. The main areas of application for micro granules are metal laser sintering, special surface designs in jewellery design and certain welding techniques.

The granulating unit can optionally be equipped with high-temperature insulation and thermocouples for higher temperatures.

5 Transport

Danger!

Lethal injuries with wrong transport by fork lift truck.

- Take care of the right position using transport device to avoid tilting of the system.
  Pick up the system only from the side, because centre of gravity is in the upper front third.
- If the fork is too small or too narrow adjusted there is a danger of system tip over from the mean of transportation.
- 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 always with fork lift truck or pallet truck.

> Please protect the induction coil against damages with sturdy foam material.

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

> Take up the system from the side.

Figure 10: lifting the weight

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 electricity supply company, the VDE and the local electricity company.
Close the system always via the 5-pin power plug to the power supply. Improper connection can result in injury and damage to the system.

Attention!

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 in a clean, dry place horizontally on. The ground must be firm and level. To the machine the following work area must be kept free: left and right of the door 1.5 m and behind the system 0.5 m. In front of 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 information in chapter 3 “technical data”:

- current,
- protective gas and
- cooling water.

Examine supply lines and connections on 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

A specialist may only perform the electrical connection. Note the information specified on the nameplate rated voltage or frequency.

The 3-phase power supply may differ max. +/- 10% from the rated voltage.

The system is supplied with a 16 A CEE plug (400 V) or 32 A CEE plug (230 V). The system may only be connected via this 5-pin power plug to the power sup-ply. The on-site to install socket must be equipped with appropriate fuses (slow).

Check the direction of rotation of the connected vacuum pump. If the direction of rotation is wrong, 2 phases of the mains supply are reversed and must be turned.

INCREASED LEAKAGE CURRENT:

Due to the built-in EMC filter, the system has an increased leakage current.

The fuse on the building electrical system must be checked. If you use a residual current circuit breaker (RCD), the RCD will probably start when the connector is plugged in, since not all 3 phases start uniformly and a high leakage current is generated. After plugging the plug, switch on the RCD.

Figure 11: RCD

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

6.3.2 Cooling water

Cooling water supply is connected to the machine by 2 hoses with inside diameter of 13 mm.

Water pressure must be 2.5 bar at minimum and do not exceed 5 bar. Water outlet has to be pressure less.

Input water temperature should be between 15 °C (59 °F) and 25 °C (77 °F). To prevent damage caused by condensation is especially recommended temperature area of 20 to 25 °C (68-77 °F).

Lime concentration should be between 3 and 8 German hardness degrees. The water should be free of pollutions.

Warning: The cooling water continues to run even if the mains switch is turned 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 4 - 6 l / min. Please use only constant pressure regulator.

Figure 12: constant pressure regulator

2x gauges in bar/PSI/kPa/MPa.

Never in liter/minute (l/min)!!!!

6.3.4 Vacuum

Here, a vacuum pump with a suction capacity of at least 21 m³ / h and a final pressure of 2 mbar should be connected. The connection must be via a special vacuum tube with a cross section inside of 13 mm carried out (article no. 40200010).

Oil level and air filter should be checked weekly.

The first oil change should be carried out after 100 operating hours. Later we recommend regular oil changes (depending on the work process) all 500 - 2000 operating hours, but at least twice a year. You need special vacuum pump oil (item number 15000910).

The oil filter and the exhaust filter should be replaced at every second oil change.

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

6.3.5 Gas outlet

Exit to the pressure reduction. This output must be kept clear at all times.

6.3.6 Vacuum pump (mains socket 16 A)

This socket is only intended for connection of a 3-phase vacuum pump (400 V AC) with a maximum output of 1.0 kVA. Internally there are backup fuses for this output. During commissioning the correct direction of the vacuum pump must be checked, otherwise the pump will be destroyed.

6.3.7 RS232

At this plug our modem 71000320 or our serial cable can be connected (article no. 50500060). Use the data management software provides by Indutherm to read system data and casting programs.

Figure 13: data management software menu

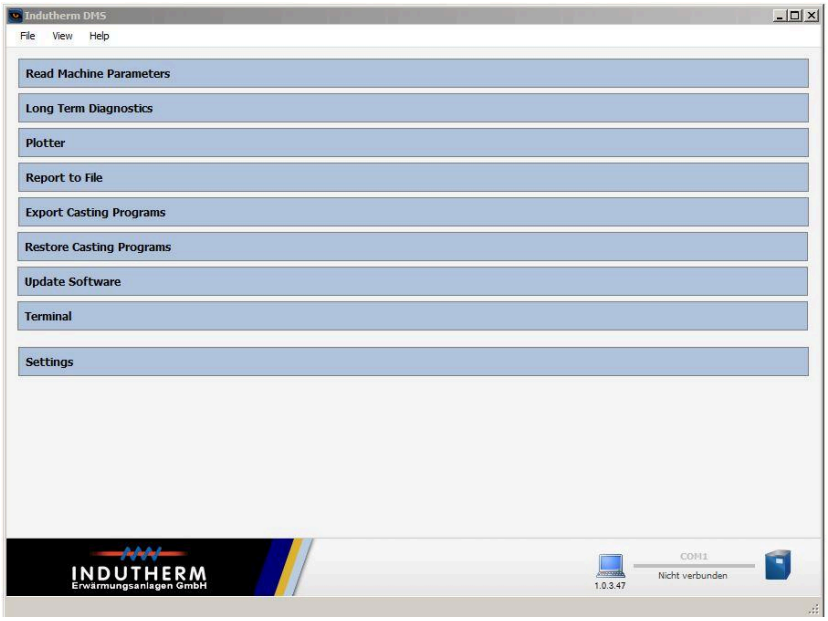


Figure 14: Machine parameters

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 insulations. Operate the system only when it's free of damages.

Warning!

Danger of burning at hot surfaces and hot metal (up to 1300 °C) Wear always personal protective equipment, when you work at the system.

Specific care is considered when using graphite crucibles. These pieces are only visually hot over temperatures of 500 °C.

Danger!

Danger of burning. When metal is molten without supply of protective gas there can happen jet of flame or blow up when opening the bell. Melt at temperatures over 500 °C better with protective gas. Apply exclusively argon or nitrogen for protective gas.

Danger!

Burning risk by leaking hot metal at compressed air failure. When protective gas failure, the sealing rod can no longer close properly. By a check valve, the pressure is maintained in the crucible. If pneumatically operated units activated, molten metal can freely run through the crucible hole.
Do not operate pneumatically operated units (e.g. sealing rod cylinder). Turn off the system immediately.

Warning!

Danger of explosions.

Dripping liquid metal can't be excluded. Place a sand filled steel tub below the system.

Attention!

At temperatures over 100 °C the cooling water circuit must work continuously. When the cooling water supply is switched off, the inductor will be destroyed. With a failure of cooling water supply the heating will be shut down immediately. Check the system before commissioning the system again.

Danger!

Risk of burns. The surface of the bell can be very hot, depending on the working temperature.

Danger!

Danger of crushing / shearing by swivelling the granulating tank.

7.2 Changing casting parts

Attention!

Switch off the system at main switch when you change consumables, e. g. crucible.

Advice!

In order to produce granules of different diameters, it is sufficient to change screw-fit in the crucible bottom.

7.2.1 Removal

> Open the bell-lid. Take out thermocouples.

> Remove “old crucible” and possible insulations.

7.2.2 Mounting

> Install “new” crucible and possibly “new” insulations.

> Put in sealing rod and close it with button “sealing rod” at front panel.

> Put in thermocouples.

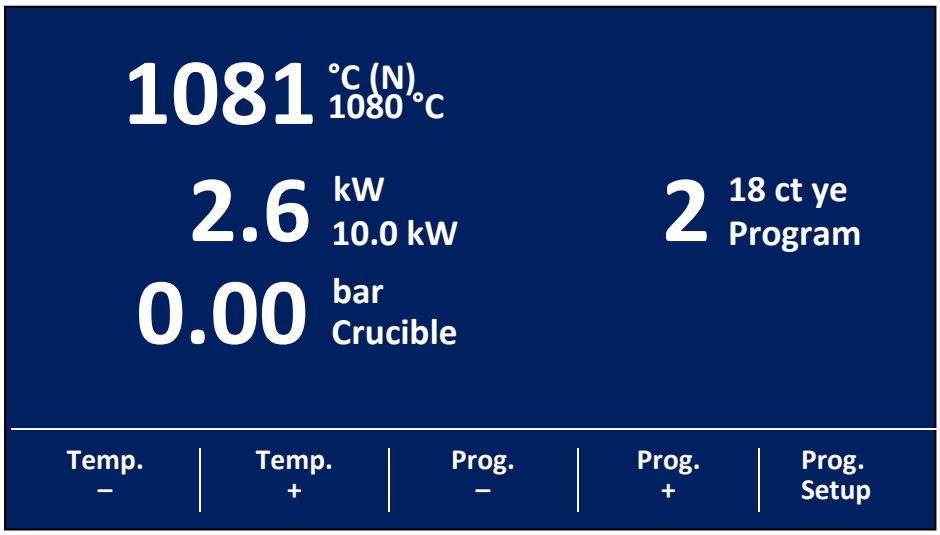
> Twist sealing rod a few times to left and right (rub surfaces), so that the crucible is reliably closed.

> Close bell-lid.

7.3 Front panel

7.3.1 LCD screen after mains switch on

Figure 15: main screen

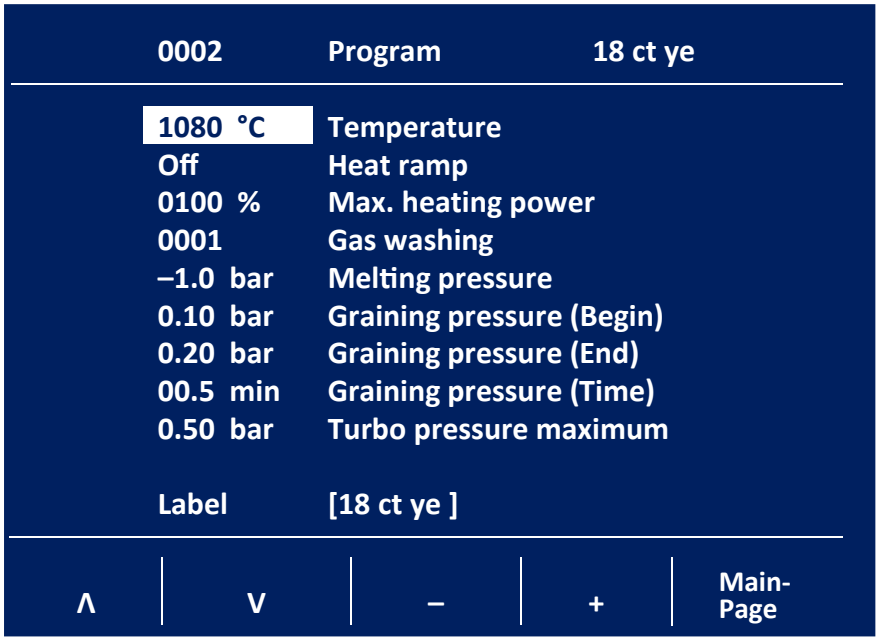


Display in the upper area:	
1081 °C	Actual crucible temperature.
1080 °C	Set temperature.
(N)	The thermocouple type N has been set and should also be used for both thermocouples.
2.6 kW	Actual heating power in kW.
10.0 kW	Set heating power in kW.
0.00 bar Crucible	Actual crucible pressure (-1 to 0.5 bar).
2 Program	Active program with name “18 ct ye”.

Display in the lower area:	
Temp. -	Lowering set temperature also during program.
Temp. +	Increasing set temperature also during program.
Prog. -	Program no. 1 will be selected.
Prog. +	Program no. 3 will be selected.
Program Setup	Allows the jump to the parameter level of the program 2.

7.3.2 Program change

Figure 16: program parameter screen



upper area = actual program name

middle area = actual program value

lower area = options

Display in upper area:			
0002	Program	'0' to '19'	Selected program to modify.
1080 °C	Temperature	'10' to '1300' °C	Set temperature inside the crucible.
Off	Heat ramp	'Off…0001 ...0200' °C/min	Slow heating of crucible is possible.
0100 %	Max. Heating power	'10' to '100' %	Here you can reduce the power for special applications.
0001	Gas washing	'0' to '5'	Number of washing cycles to be created in the melting chamber (vacuum followed by backfilling with protective gas).
-1.00 bar	Melting pressure	'-1.00' to '0.00' bar	Set pressure during heating up.
0.10 bar	Graining pressure (Begin)	'0.00' to '0.50' bar	Set value for pressure in melting chamber at the start of the granulation process.
0.20 bar	Graining pressure (End)	'0.00' to '0.50' bar	Set value for pressure in melting chamber at the end of granulation process (maximum 0.5 bar possible).
00.5 min	Graining pressure (time)	'00.0' to '30.0' min	Estimated granulation process time.
0.50 bar	Turbo Pressure Maximum	'0.00' to '0.50' bar	Maximum short-term value of the overpressure if the turbo pressure button is pressed (e.g. for cleaning the nozzle holes).
Label	[ ]	'a-z, A-Z, 0-9'	Opportunity to give a name to the actual program using the +/- keys (alphabet capital and small letters, numbers, symbols) and arrow keys (next character spacing).

On the bottom level is shown:	
Arrow key up	Move to the set value one position higher.
Arrow key down	Move to the set value one position lower (here: to “Heating power”).
–	Lower the set value (here: 1079).
+	Rise the set value (here: 1081).
Main page	Return to the main display.

7.3.3 Predefined Casting programs

Figure 17: pre-set programs

GU500						**GU500 micro**
material		**Granul.**	**Test**	**18 ct ye**	**with zinc**	**CuSn**
program-number		**10**	**18**			
Temperature	°C	1000	0010	1080	melt.+150	1150
Heat ramp	°C/min	Off	Off	Off	Off	Off
Heating power	%	0100	0100	0100	0100	0100
Gas washing		0001	0001	0001	0001	0001
Melting pressure	bar	-0.50	-1.00	-1.00	0.00	0.00
Graining pressure (Begin)	bar	0.1	0.50	0.10	0.00	0.00
Graining pressure (End)	bar	0.2	0.50	0.20	0.00	0.20
Graining pressure (Time)	min	02.0	02.0	00.5	00.0	1.0
Turbo pressure maximum	bar	0.20	0.50	0.50	0.50	1.5
Label		Granulate	InduTest	18 ct ye		CuSn

7.3.4 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.

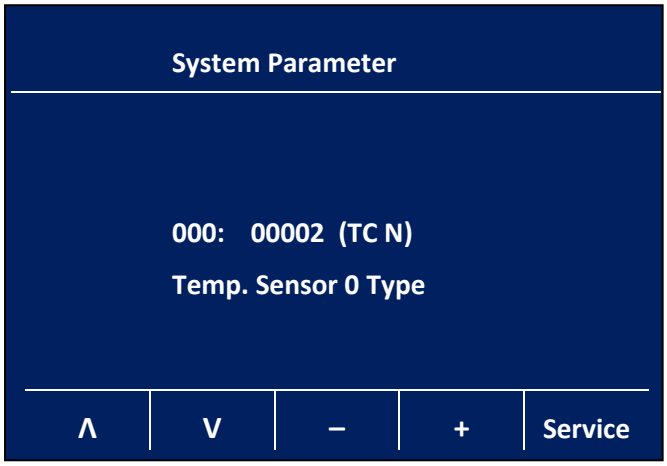


Figure 18: System parameter

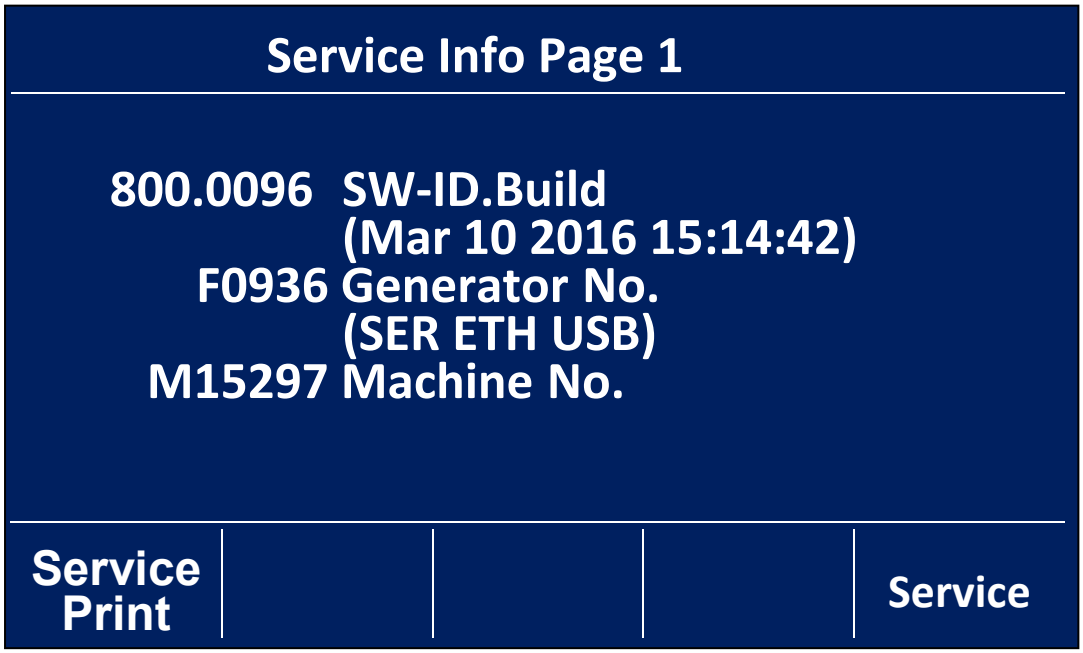
Note:
Please refer to the explanations for the parameters in the attachment software documentation. The adjusted values should be changed with care and usually after consultation with the Indutherm service staff.

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.

7.3.5 State Level

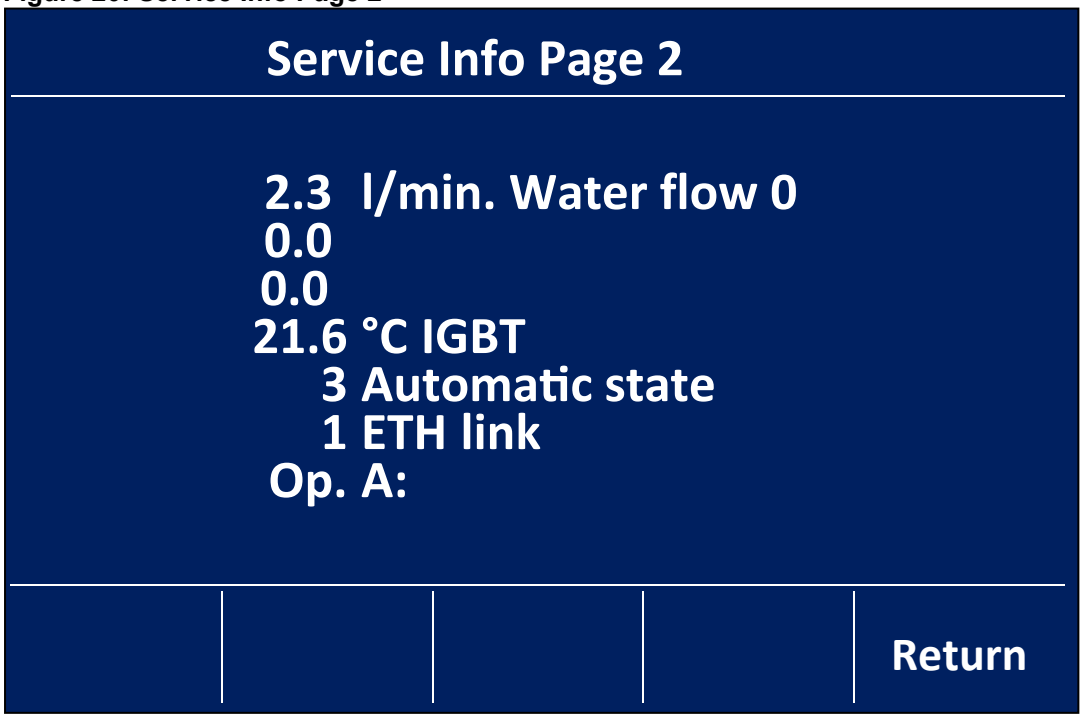
By pressing the “Service”-button once, you see the software ID, generator number and machine number.

Figure 19: Service Info Page 1



Pressing ‘Service’ second time display switches to the second service info page amongst other with important information on the cooling water flow, generator temperature, machine state and signal strength of inbuilt modem (Op. A/ if modem is installed). The point "Automatic state" is not customer information. This is the state of the internal sequence control. The number is for development purposes and varies as a function of the software and the machine. The 1 in ETH link means a working network connection. The water sensor “Water flow 1 and 2” are not used in the GU500 and always remains at 0.0.

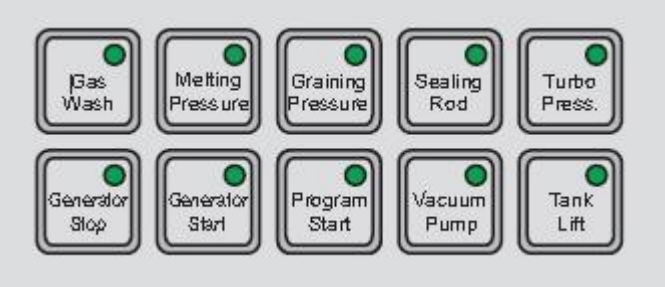
Figure 20: Service Info Page 2



After pressing ‘Return’ switch display back to main page.

7.3.6 GU500 Front panel below display

Figure 21: buttons of front panel



Top row:	
Gas Wash*	Starts the gas washing cycle (s).
Melting Pressure*	Creates the melting pressure in the melting chamber.
Graining Pressure*	Creates the pressure in the melting chamber defined for the start of the granulation process.
Sealing Rod	With pushing this key, the sealing rod opens or close to let flow liquid metal in the granulation tank at request. If it is open the granulation process starts and a timer is started which shows the granulation process time. You can deactivate the warning W077 by pressing the button ‘sealing rod’ for 3 seconds. This is useful when you want to clean an empty warm crucible, but the granulation tank is swivelled out.
Turbo Press.*	Adds overpressure to the inductor housing as long as the button is pressed (up to “Turbo pressure maximum”).
* pressures and cycles as defined by the formerly selected program	

Bottom row:	
Generator Stop	Switch off generator. Stops heating.
Generator Start	At this key you can switch on generator. Working generator regulate temperature basically to the set temperature (see above temperature).
Program Start:	With this button the selected granulating program starts, all parameters are transferred to the memory and the heating begins.
Vacuum Pump	Switches vacuum pump on and off (therefore you have to connect pump at backside socket of GU500).
Tank Lift	Release the granulation tank and the barrel sinks down. Lifting happens automatically when display demands “swivel in graining tank” and you move tank to complete-in position.

7.4 Granulating

Before starting check crucible, sealing rod and crucible insulation for dirt residues/possible damages. It is recommended to use a **vacuum cleaner** for the entire inductor. The metal filter (left of the sealing rod) should be taken out and cleaned with compressed air.

Bei der Anwendung von Druckluft darf nicht in den Raum geblasen werden und es muss eine Staubschutzmaske benutzt werden.

Program selection:

This machine contains actually one pre-set program.

Program 10 = Granulate

Program 18 = Test-program from INDUTHERM for checking the system without heating (10 °C set temperature).

Suggestion for general work process:

A crucible with a hole of a 2 mm diameter is recommended.

Advice!

For producing granules of even smaller diameter, you can buy crucibles without hole for self-drilling of, for example, 1 mm hole.

Figure 22: crucible without hole

1. Open cooling water and protective gas supplies.
2. Switch on mains switch and vacuum pump.
3. Fill the tank with water until overflow is reached.
4. Examine the sealing rod in raised position for easy moveable.
5. Then lower the rod into the crucible and grind in the sealing rod into the crucible bottom hole (rotating movement).
6. The contact pressure plate (Figure at ch. 4.5) should be swivelled in.
7. Set the desired program and press “Program Start”. Program process will be started and all values are transferred to the memory.
8. If there is “Gas Wash” request, please press this button. This is only possible with swivelled in contact pressure plate.

Recommendation by INDUTHERM regarding “Washing cycles”:

1 cycle is enough for the usual alloys and

2 cycles if there is still manganese in the alloy.

9. After the optional wash cycles press the button “melting pressure” for creating the pressure during heating (vacuum or over-pressure). Only possible with the contact pressure plate.
10. (If the LED in “Generator Start” is not alighted and the generator don’t heat already after pressed “Program Start” then please press “Generator Start”.)
11. If the machine reaches set temperature and the metal is completely molten please hold the temperature for at least 5 minutes to get a homogeneous mixing. If you make the alloy in the machine, then wait total 10 minutes.
12. Granulating tank should be filled with sufficient water and cold water should circulate. Regulate the water inlet through the spray nozzles in a way that the water is in motion, but does not splash. Adding of 2-5 % of ethanol are recommended.
13. Press “Tank Lift”. Move aside contact pressure plate und swivel barrel in the machine. Lift granulation tank with button “Tank Lift” again.

Attention!

The contact pressure plate can be hot!

14. Press button “Graining Pressure” and begin the pressure build-up.
15. Press key “Sealing Rod” to start the granulating process. Timer is starting to count. The metal flows now slowly in the granulating tank. Due to the water movement, the metal is torn apart, thus producing granules.
16. In the moment the crucible is complete empty, please press key “Sealing Rod” to close the crucible bottom. Then press “Graining pressure” in Off-State and stop heating by button “Generator Stop”.
17. Let the system closed with temperatures above 500 °C.
18. Below 500 °C you can open the lid and check crucible with sealing rod.
19. Move the granulating tank aside and take out inlet with the granules (Eventually you have to press button “granulating tank” to release the barrel).

Now you can start a new granulating process at step 3!

7.5 Hints for granulating under vacuum

you are using an alloy **without** zinc, you can also melt the metal under vacuum to degas the alloy, highly recommended for silver/copper alloys.

Lift the contact pressure plate against the bottom of the crucible chamber with the button “tank lift” and press the button "Vacuum Pump". The pump starts and the vacuum plate is sucked against the crucible chamber. The display "Crucible" should show now a negative pressure. If the metal has dissolved gases, you can see it boiling and bubbling. Wait until the melt becomes quiet (it can take around 15 minutes). Switch off the vacuum pump. When the vacuum pump is stopped, the vacuum inside the crucible chamber is automatically released with inert gas.

Please note: Attention, the plate can be hot!

7.6 Tips for more satisfying granulating results

The most important parameters for influencing the granulation process are:

1) The excess temperature of the melt (liquidus temperature of the material + x °C):
   a) You generally need a certain excess temperature of at least 50-80°C depending on the material and the nozzle diameter.
   b) To reduce the viscosity of the material, you can increase the overtemperature.
   c) Be aware that your alloy components can evaporate due to overtemperature (materials with evaporation tendency e.g. Zn).
   d) Be aware that each additional temperature must also be cooled down. If you get flakes instead of granules, this could be due to the overtemperature and also to the distance between the nozzle outlet and the water surface, as the material could not create a round shape before solidification.
2) The diameter of the nozzle outlet:
   a) As a general rule of thumb, the Granule diameter is approximately twice the nozzle diameter.
   b) Depending on the surface tension and viscosity of the metal, the overtemperature of the metal must be adjusted in relation to the nozzle outlet diameter.
3) Differential pressure between melting chamber and Granulation container
   a) When you start your process, there is a certain hydrostatic pressure in the crucible corresponding to the level of the liquid melt. This level will decrease significantly during the granulating process. To keep this pressure constant, you can set an overpressure in the melting chamber "Start granulating process", "End granulating process".
   b) The material mass flow is strongly dependent on the differential pressure. The higher the material mass flow, the more energy must be absorbed by the water in a certain time.
   c) Keep the material mass flow constant to achieve a close yield of the granule size.
   d) If you have difficulties getting the metal through the nozzle outlet and do not want to increase the overtemperature (reduce viscosity), you can also try to increase the differential pressure or increase the nozzle outlet diameter.

4) Gap between the nozzle outlet and the water surface:
    a) Depending on the surface tension of the material, it takes a certain time for a spherical shape to form. This is also dependent on the mass of the granulate (nozzle diameter & material mass flow).
    b) The higher the differential pressure in the melting chamber, the faster the material is accelerated when exiting the nozzle and the less time the material has to take on a drop shape.
    c) In case of non-round granules, you could try to increase the gap or adjust other parameters (overtemperature, outlet diameter, differential pressure).
5) Water temperature:
    a) A water temperature of 20-30°C with an ethanol content of 2-5% is recommended. As hot material falls into the water, the water temperature rises continuously. Ensure a constant water flow that guarantees a constant water temperature (constant solidification behaviour).
    b) The water temperature influences the solidification process and thus also the grain size of the granulate. Keep it constant to achieve a consistent quality.
    c) Water (H2O) contains oxygen, please also note the following section.
6) Alcohol content in water:
    a) To avoid oxidation: When hot material falls into the water-alcohol mixture, the alcohol forms a vapour bubble due to the lower vapour pressure compared to water, so that the oxidation that would come from the water is reduced. This effect could be observed especially with non-precious metals like Cu e.g. 925 Ag (AgCu mixture).
    b) To optimize sphericity (spherical shape): The alcohol vapour bubble gives the material the possibility to form a spherical shape in a more or less undisturbed state.
7) Melting chamber atmosphere ("washing", "melting pressure"):
    a) Washing: In order to avoid oxidation of the material, but also to reduce wear of the graphite parts, it is recommended to perform a washing cycle (evacuating the melting chamber by vacuum and refilling with inert gas) before starting the heating.
    b) Vacuum: Melting can also be done under vacuum. This is only recommended if there is no risk of evaporation of alloy components. Often used for fine silver, which tend to contain gases, to degas the material.

8) Other general recommendations:

   a) The ratio between the diameter of the Granulation nozzle and the size of the granulate depends on the type of material (surface tension, viscosity, distance between metal outlet and water surface, pressure in the melting chamber, etc.).

   b) The hardness and granule structure can be influenced by the cooling rate, which is important, among other things, if the granulate is to be used as a semi-finished product.

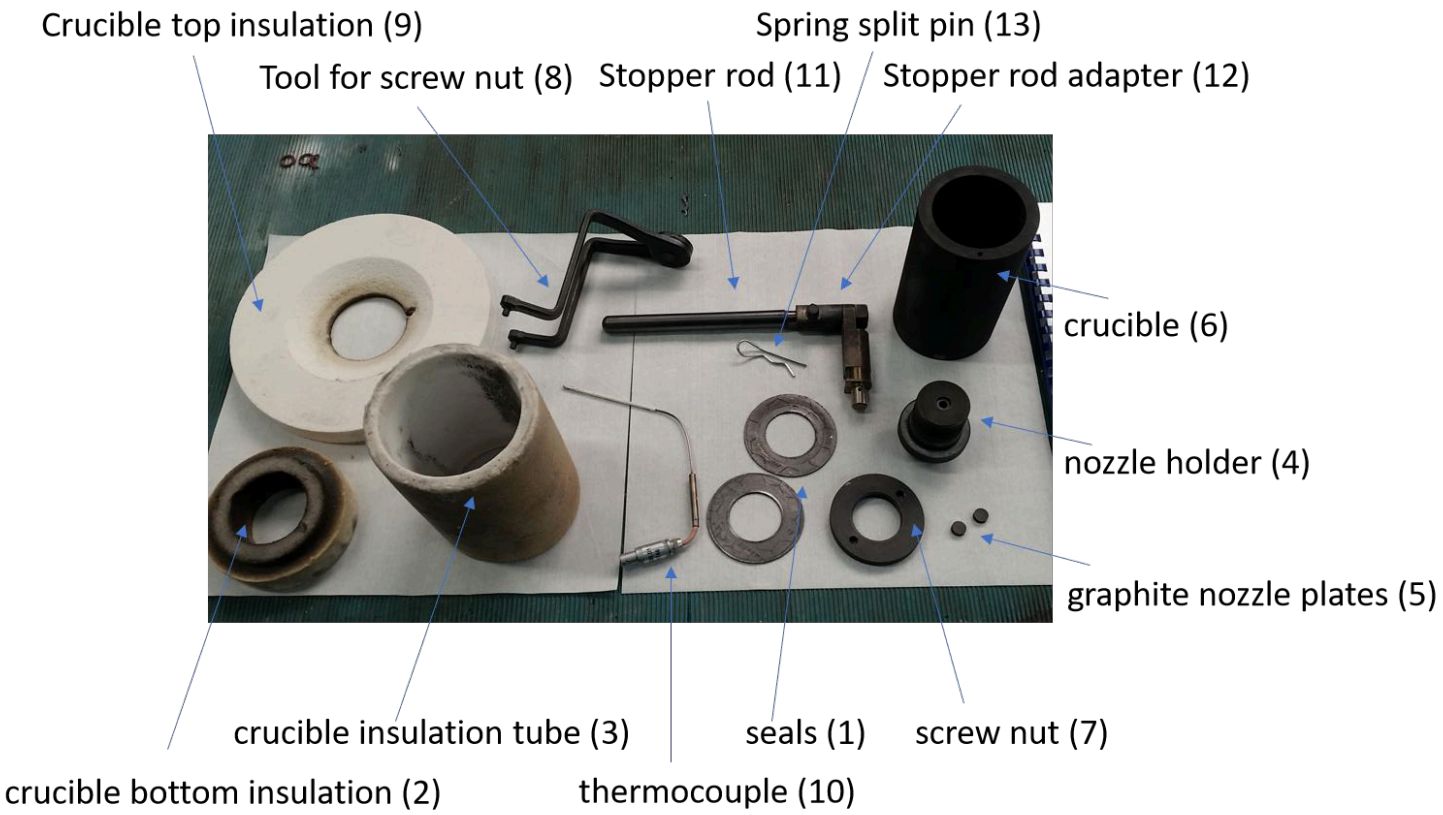
   c) For the first attempt, use only 1 nozzle hole or a maximum of 3 holes with 2-3mm to avoid bonding/melting of the granulate, but to be sure that the material passes through the nozzles in a stable way. From there you can optimise your process.

Please note that INDUTHERM cannot be held responsible for dissatisfying casting results.

7.7 GU500 Micro

7.7.1 Overview on parts, tools and consumables

Figure 23: Overview on parts, tools and consumables Micro



7.7.2 Mounting of spare parts and consumables

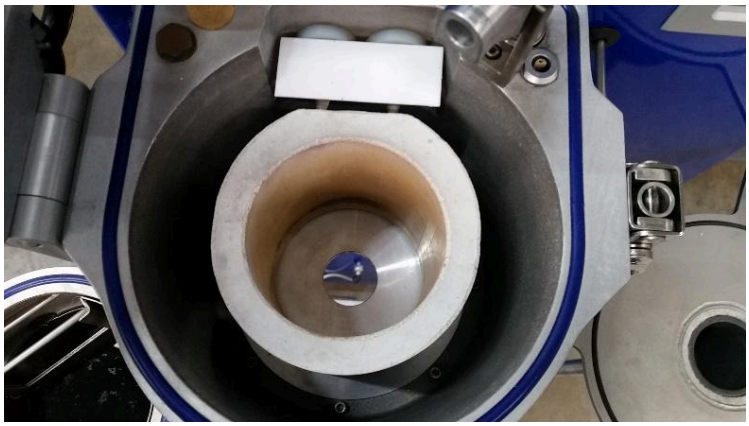
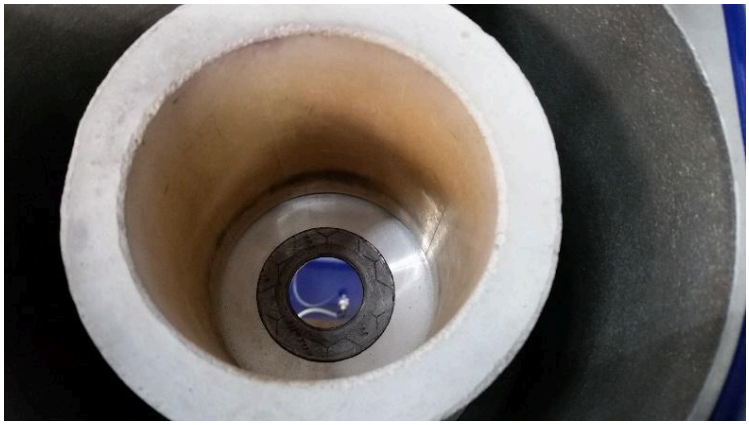
Figure 24: empty chamber View into the empty melting chamber with the water-cooled, embedded inductor in the middle.	
Figure 25: seal Place a graphite seal (1) on the bottom plate in centered position.	
Figure 26: bottom insulation On top place the crucible bottom insulation (2)	
Figure 27: crucible insulation Slide in the crucible insulation tube (3) so that it sits tight on the crucible bottom insulation.	

Figure 28: nozzle

Prepare the microgranulation nozzle holder (4) and a nozzle plate (5). Clean the parts from any metal residue from former trials.

Prepared graphite nozzle plates contain nozzle diameters with 0.3, 0.5 and 1 mm , respectively.

Graphite and Ceramic nozzle plates without prepared pour holes are delivered, too.

Figure 29: nozzle holder

The nozzle holder, with correctly inserted nozzle plate, must be screwed into the bottom of the crucible (6).

Figure 30: slide in crucible

Carefully slide the graphite crucible with nozzle holder into the center of the inductor until it sits tight on the bottom graphite seal.

Pay attention to the position of the hole drilled in the crucible wall so that it is directed towards the plug for the thermocouple.

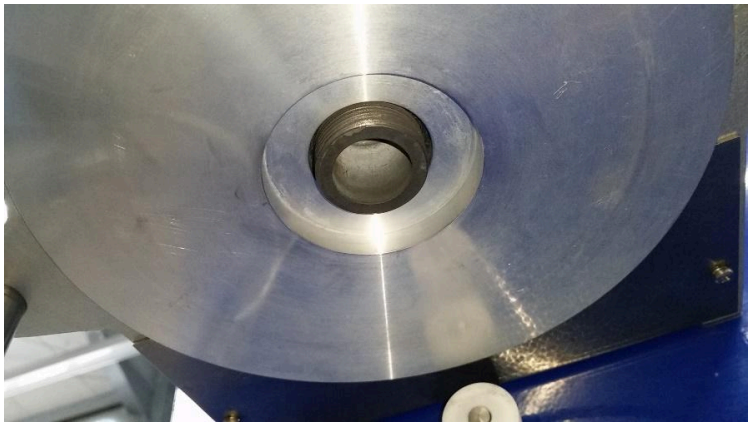
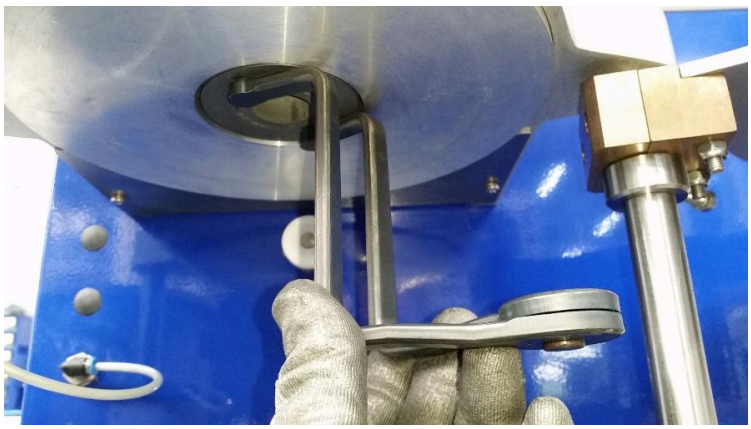
Figure 31: thread visible The graphite thread must stand out of the bottom plate.	
Figure 32: second seal Place the other graphite seal (1) on top of the large graphite nut (7).	
Figure 33: special tool Screw the nut with seal on the thread in order to tightly fix and seal the nozzle holder with the bottom plate. Use your fingers first and eventually use the special tool (8).	
Figure 34: top insulation Place the crucible top insulation (9), also called filling cone, on the top of the crucible such that the cut-out is in line with the hole drilled into the crucible wall.	

Figure 35: thermocouple put-in Insert the thermocouple (10, covered with the ceramic protection tube) into the hole drilled in the crucible wall and plug in the connector.	
Figure 36: vacuum-cleaner Carefully clean the inside of the crucible and especially the opening of the nozzle plate with a vacuum cleaner.	
Figure 37: sealing rod Insert the sealing rod (11) in the sealing rod adapter (12) and fix it with the screw.	
Figure 38: put in sealing rod Connect the sealing rod with adapter to the sealing rod holder and fix it with the spring split pin (13).	

Figure 39: sealing rod button Press button “sealing rod” to move the sealing rod down. When the LED lights up, the sealing rod is open/up and when the LED in the key goes out, the sealing rod is closed/down.	
Figure 40: swivelling sealing rod Tighten the seal of the sealing rod against the pour hole in the bottom of the crucible by swiveling the sealing rod to the right and left by ~ 45° in each direction.	
Figure 41: fill in material Weigh and fill in the metal.	

7.7.3 Granulating process

Figure 42: swivel in vacuum plate

Close the lid and fix it on the side with the closure.

Swivel in the so-called vacuum plate, so that it closes the melting chamber from the bottom.

A graphite container is inserted in the center of the vacuum plate for safety reasons (leakage of molten metal during the melting process).

Figure 43: adjust program

Select a program and control / modify the settings.

Press button “gas wash” to start an evacuation and backfill cycle (“washing cycle”). Usually 2 cycles are recommended (not only 1 as on the display). The vacuum pump is started automatically, but must be switched off manually later (button “vacuum pump”)

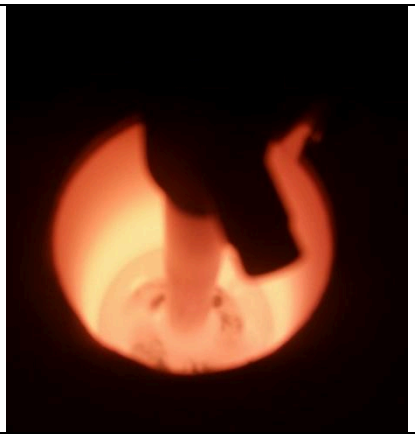
Afterwards press button “melting pressure”. The system will create the pre-set pressure in the melting chamber.

Then press button “ Program start”. The system will start heating with the pre-set ramp and/or power limit to the pre-defined set temperature.

Figure 44: heating

The system will heat until the pre-set temperature is reached in the crucible wall (the metal is not yet molten) and will keep that temperature.

The melting process of the metal requires some more time and heating power.

Figure 45: metal liquid Keep an eye on the metal and heating power. Once the metal is completely molten and the temperature is stabilized inside the melt and crucible, the heating power levels off at a lower level.	 
Figure 46: slide in granulation tank Slide out the vacuum plate by pressing “tank lift”. Slide in the granulation tank filled with water + alcohol (a few 2-5 %).	 
Figure 47: start process Prepare the microgranulation process by pressing “Granulation pressure”. The system will create the preset “BEGIN” value for the granulation pressure. Start the microgranulation process by pressing the button “Sealing rod”. The rod will lift up and the metal should start pouring into the water tank creating a distinct sound. A timer will count upwards and the granulation pressure will increase following the ramp defined in the program (END pressure, estimated granulation TIME).	
If the process does not start, make sure the sealing rod has lifted up: press button “sealing rod” multiple times and watch it moving through the window.	If it has definitely opened, and still no metal is flowing, then try to kick-off the process by pressing the button “Turbo pressure” for a few seconds. Also, at the end of the process, press “Turbo pressure” to clean the nozzle from residual melt.

7.7.4 Typical results and process parameters

Figure 48: Typical results and process parameters

Note the droplet size and its (non-) uniformity. The relation between nozzle size and granule size is typically: d (granule) / D (nozzle) = 1.5 – 2.5.

In an ideal world the granules would have a uniform size. A constant metal mass flow rate from beginning to the end of the process should help. Theoretically, this can be achieved by an increase in granulation pressure during the process, such that it compensates for the drop in hydrostatic pressure of the molten metal on the nozzle during pouring. The granulation BEGIN pressure must be high enough to kick-off the process and depends on the nozzle size (see further below). The pressure difference between BEGIN and END pressure should depend on the metal load in the crucible, more precisely the height of molten metal in the crucible.

- 10 cm water = 10 mbar
- 10 cm bronze ~ 80 mbar

Nozzle diameter **1 mm:**	Metal mass flow rate **~ 30 kg/h (Bronze)** Granulation Pressure BEGIN: **0.0 bar**
Nozzle diameter **0.5 mm:**	Metal mass flow rate **~ 12 kg/h (Bronze)** Granulation Pressure BEGIN: **0.1 bar**
Nozzle diameter **0.3 mm:**	Metal mass flow rate **~ 6 kg/h (Bronze)** Granulation Pressure BEGIN: **0.2 bar**
Nozzle diameter **0.1 mm:**	Metal mass flow rate **~ 1 kg/h ((Bronze estimated)** Granulation Pressure BEGIN: **0.5 bar** Drilling holes as small as 0.2 and 0.1 mm in diameter or lower is not easy**.** The nozzle plates are 4 mm high. It may be requird to drill a larger hole first and then use the small drill only for the last 2 or 1 mm, respectively.

7.8 Error diagnosis

There are two types of disorders:

- errors and
- warnings.

When ever an error occur the heating stops and an error code will be on display.
With slight disturbances only warning code be displayed. You can see an error code in display.

7.9 Troubleshooting

Only an expert may open the system.

Trouble	Reason
System can not switch on.	• Missing power supply. • Line circuit breaker in machine (at rear side) has triggered.
Heating don't work.	• Cooling water supply not switched on, error display "E010". • Protective gas supply not switched on, error display "E013". • Thermocouple not in right place or faulty, display of crucible temperature "OFbE". • Generator overheated, error display "E021". • Other error, error display "Exxx". • Exhibition mode activated (P.155 = 0?).
Temperature indication faulty.	• Wrong thermocouple programmed, look at annexe, parameter „P.000". • Thermocouple faulty. This will also turn off generator.
Low generator output.	• Set-point of temperature regulator too low. • Wall thermocouple at its set threshold.
Sealing rod don't open	• Too less input protective gas pressure. • Vacuum pressure casting tank not swivelled in.
Pressure problems in crucible chamber.	• Error in the vacuum supply (with vacuum).

Additional error messages in annexe.

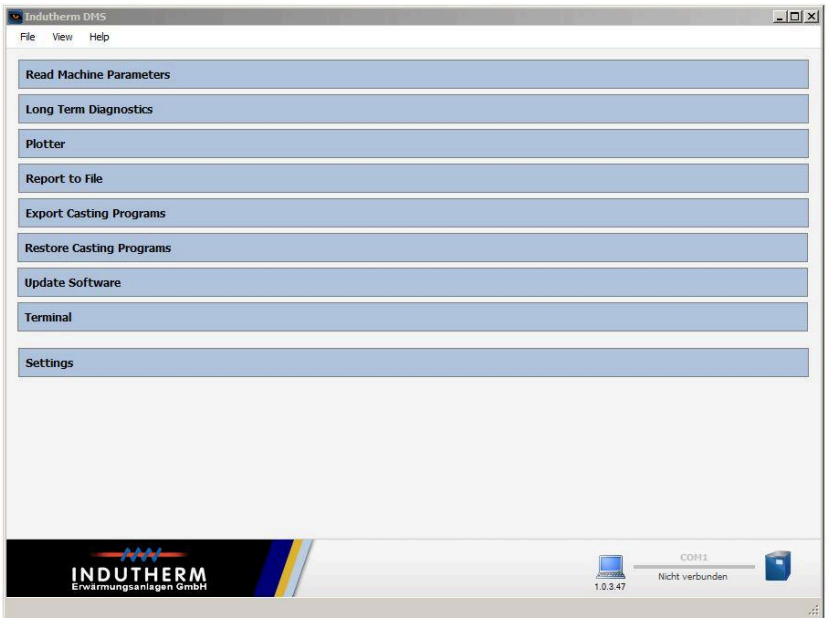
7.10 Service

Whenever you need technical support from *INDUTHERM Erwärmungsanlagen GmbH*, we'd like to ask you to provide following information right from the beginning:

- service number **M26020 F** which you can find at the mains switch,
- from manual cover page or from label at the rear side.

7.10.1 DMS (Data Management Software) for Service

Figure 49: data management software menu



Current Version: V1.0.3.56
Selectable Topics: - Read Machine Parameters (read out diagnostic data/for service purposes) - Long Term Diagnostics (continuous data ample over a long period) (for research / for research documentation / for service purposes) - Report to File (store casting report to hard disk / same information as printed on panel printer) (for production documentation / for research documentation) - Export Casting Programs (read out current casting programs) (for external data backup) - Restore Casting Programs (restore backup data) - Update Software (for service purposes)
Physical hardware connections: - RJ45 Ethernet connection - Serial RS232 (V24) connection, 0-modem-cable (Rx-Tx-crosswise)
Required platform: - Windows hardware - Operating System Windows 7 or higher

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 granulating machine must be kept always close always.
- No work carried out on energized parts.
- Loose connections eliminate.
  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 work is carried out there.

Warning!

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

Caution!

Health hazard due to inhalation of fibre particles.

- Store the crucible shield and insulation in a dustproof package.
- Remove the material immediately before installation.
- Don’t shatter crucible shield and isolation.
- Pack the materials immediately dustproof after removal and dispose of these materials in this packaging.

8.2 Maintenance schedule

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

Daily (before casting)

Warning!

Burning hazard because of leaking molten metal.

The system must not be operated without a sealing rod for security reasons.

The tip of the sealing rod must stay in the pouring opening even when sealing rod is open.

With built-in and closed sealing rod the sealing rod-cylinder must not be on the lower end position, otherwise the sealing of the pouring hole is no longer guaranteed.

Check in case of an error necessarily the extent of sealing rod, graphite ball, crucible and the crucible bottom insulation.

- Remove thermocouple, crucible and insulating materials. Clean inductor housing carefully with a vacuum cleaner. Before installing check components and replace if necessary.
- Clean the metal filter on the left of the sealing rod.

Figure 50: Filter crucible chamber

With using of compressed air wear a dust proof mask and must not blow in the room.

- Check and replace white filter for vacuum if necessary.

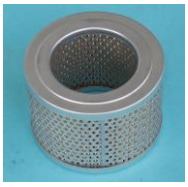
Weekly

- Apply on the thread of the sealing rod high-temperature grease.

Every 4 months

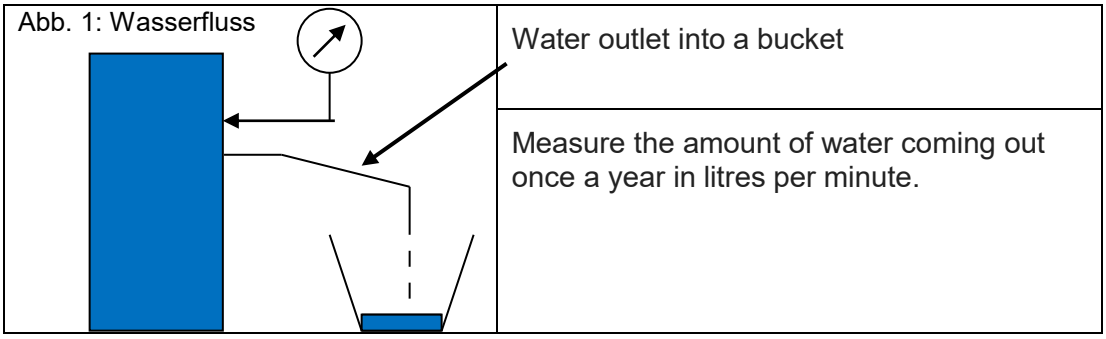
- Check the vacuum filter and the oil separator filter of the vacuum pump. Check oil level. Check/clean air filter. Renew it.

Figure 51: air filter of vacuum pump



Every year

- Cooling water system with about 25% citric acid rinse for about an hour. After 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.

Warning!

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.

Figure 52: red CEE-plug

For electrical testing or maintenance, the machine **must** be separable from the power supply via the red CEE plug, as described in chap. 6.3.1 Installation required.

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

- Deliver spent lubricants from at the hazardous waste collection point.
- Spilled lubricants, immediately sprinkle with binder and disposed of after binding as hazardous.
- Meet catch precautionary, spilled feed 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, 75045 Walzbachtal
Product type:	Granulating machine
Machine type:	GU500 F-generator, GU500 micro F-generator
Serial number:	10061 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

Directive 2006/42/EC on machinery 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 13850:2015 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.

Directive 2014/30/EU 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 Erwärmungsanlagen GmbH for 10 years.

city/date/signatory: Walzbachtal/2026-01-22/Peter Hofmann, chairman

10.3 Circuit diagram

10.3.1 Circuit diagram machine with 3x 400 V

Figure 53: circuit diagram - power part 400 V

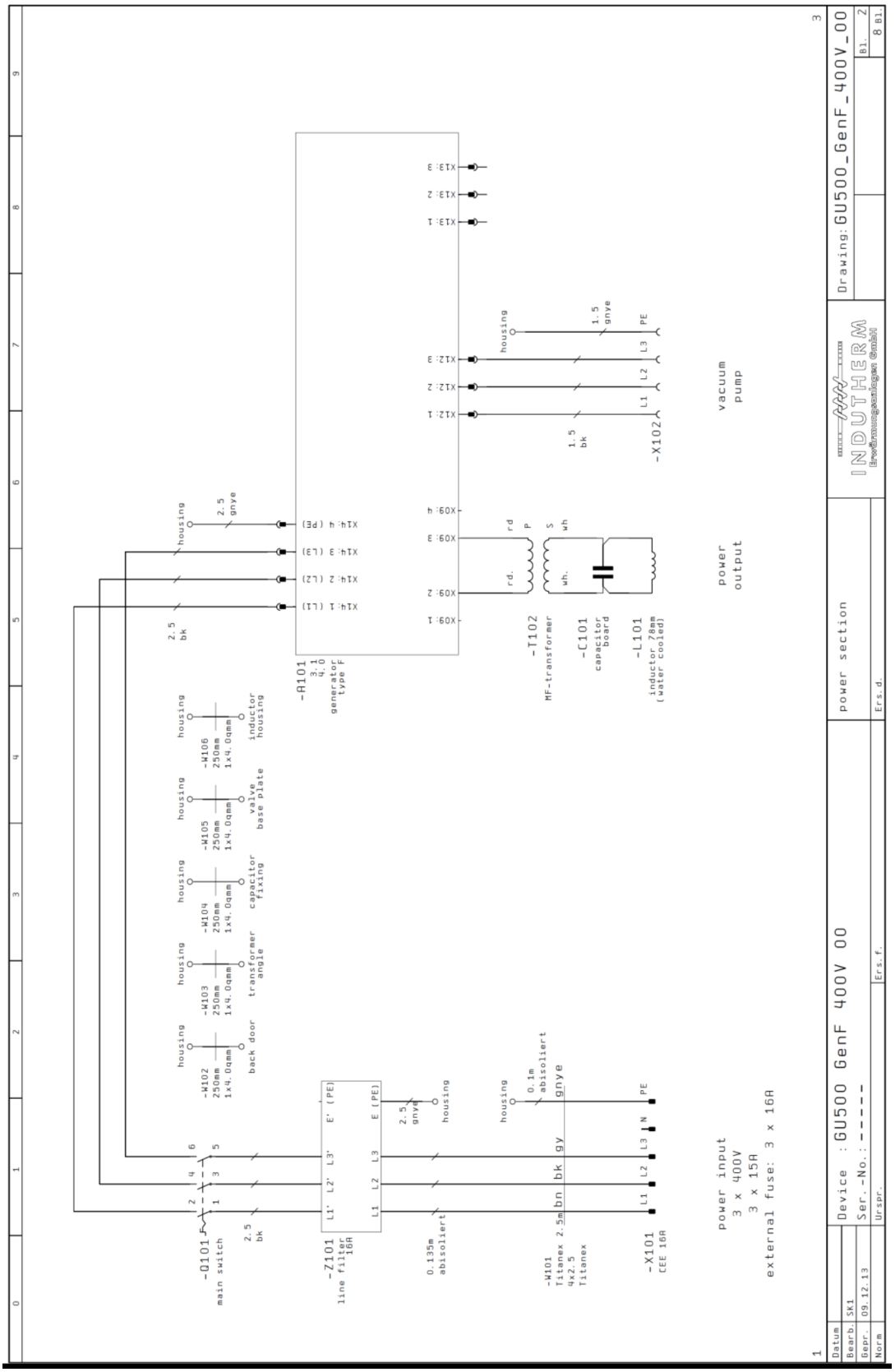


Figure 54: circuit diagram - control

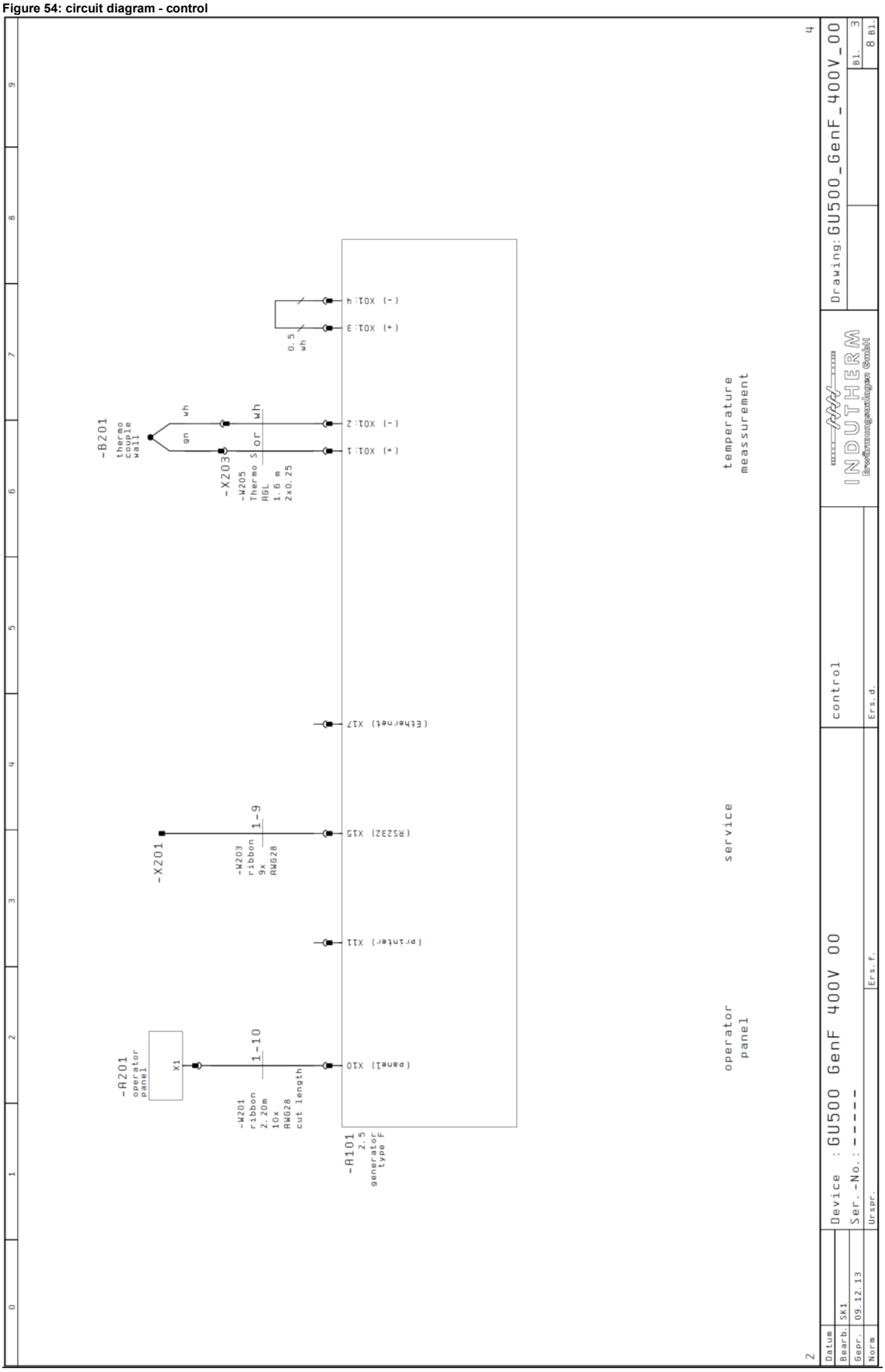
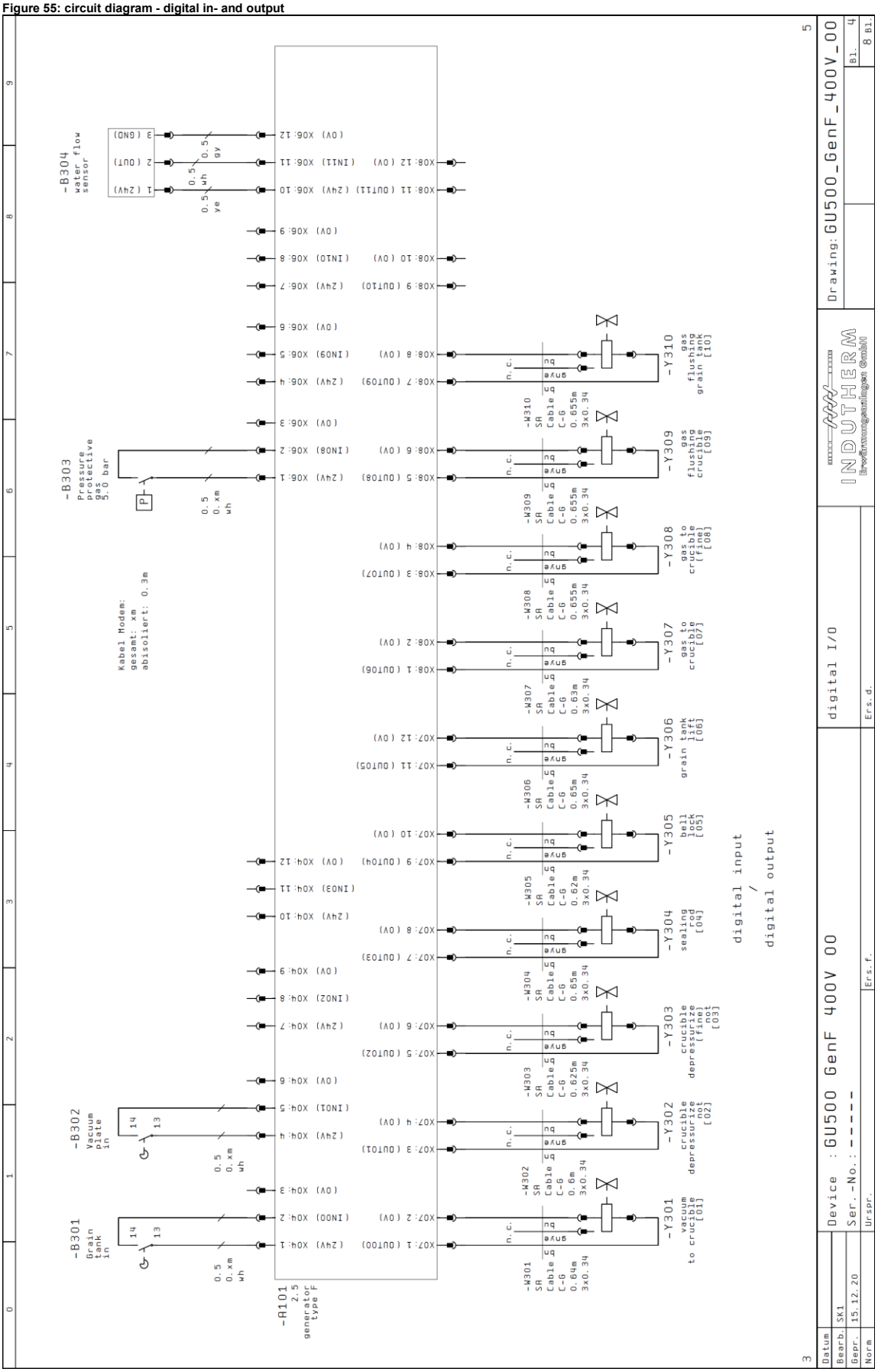
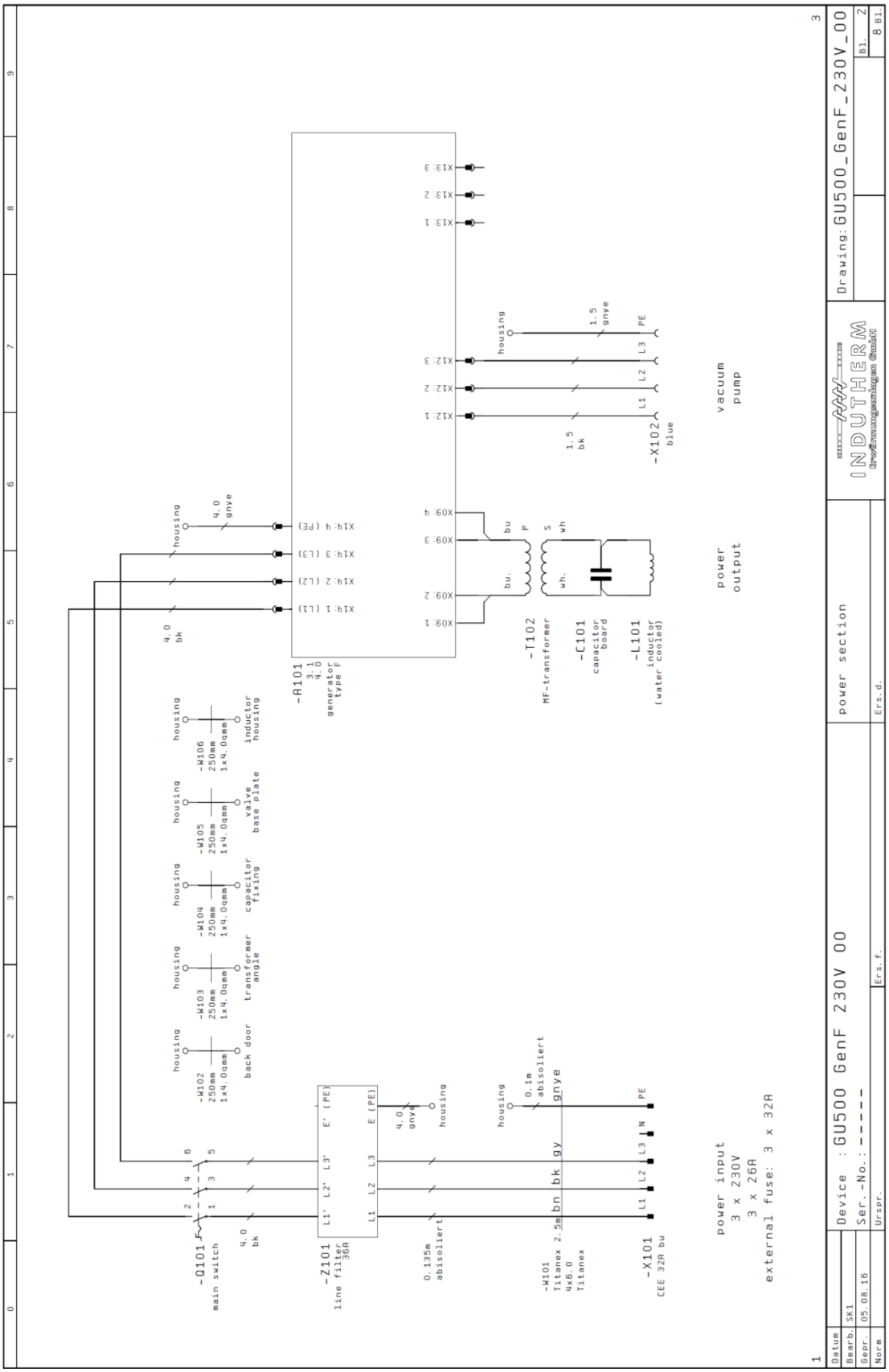


Figure 55: circuit diagram - digital in- and output



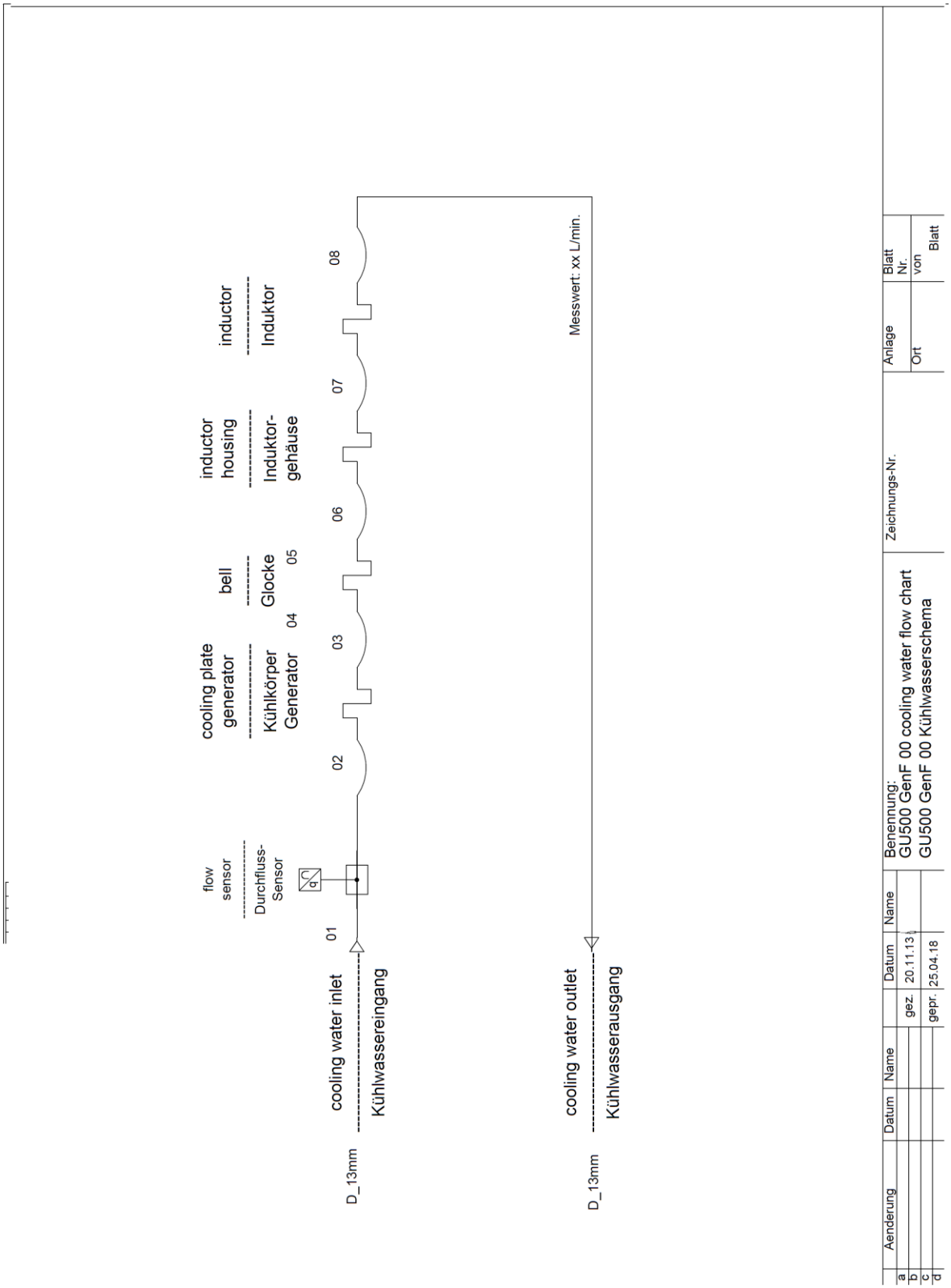
10.3.2 Circuit diagram machine with 3x 230 V

Figure 56: circuit diagram - power part 230 V



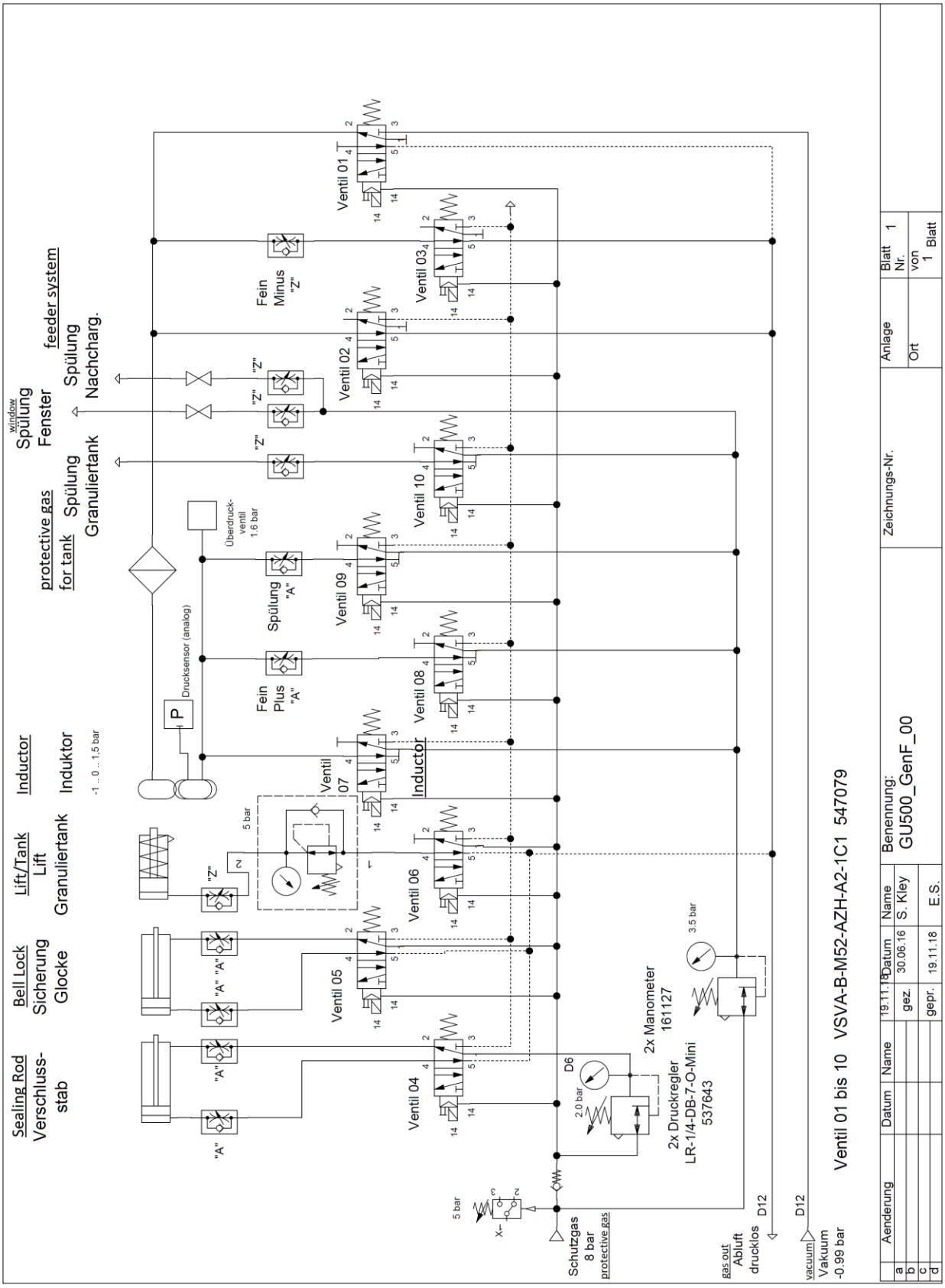
10.3.3 Cooling water circuit

Figure 57:Cooling water circuit



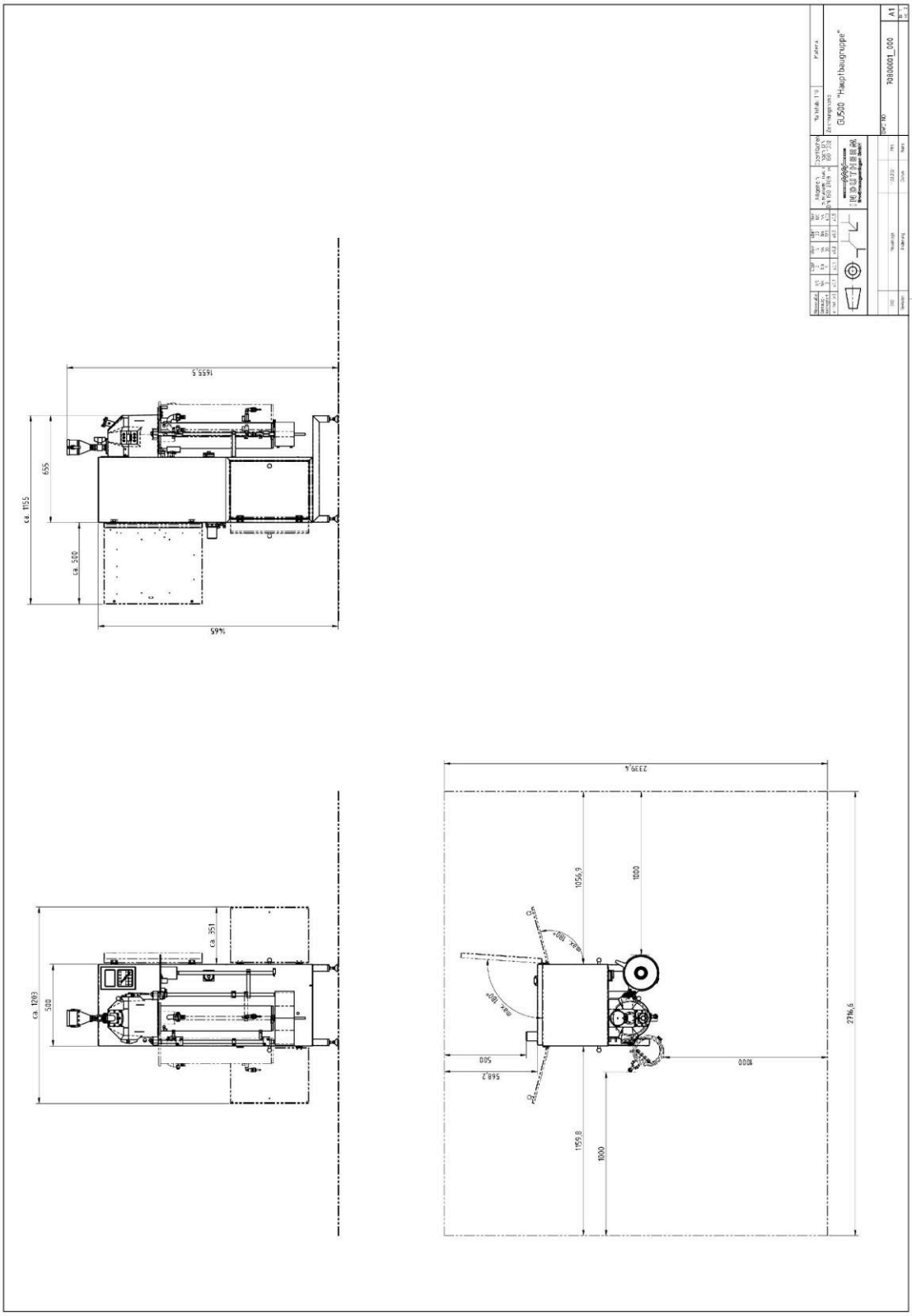
10.3.4 Pneumatic circuit drawing

Figure 58: Pneumatic circuit drawing



10.4 Technical Layout

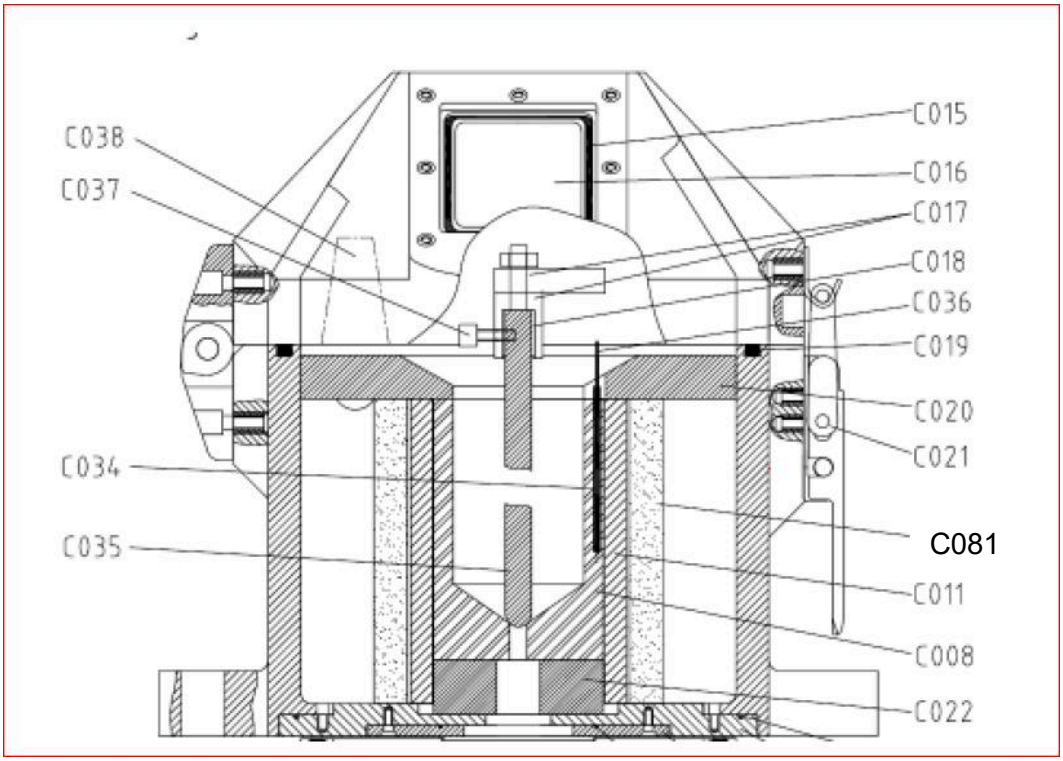
Figure 59:technical layout



10.5 Sectional view of replacement parts

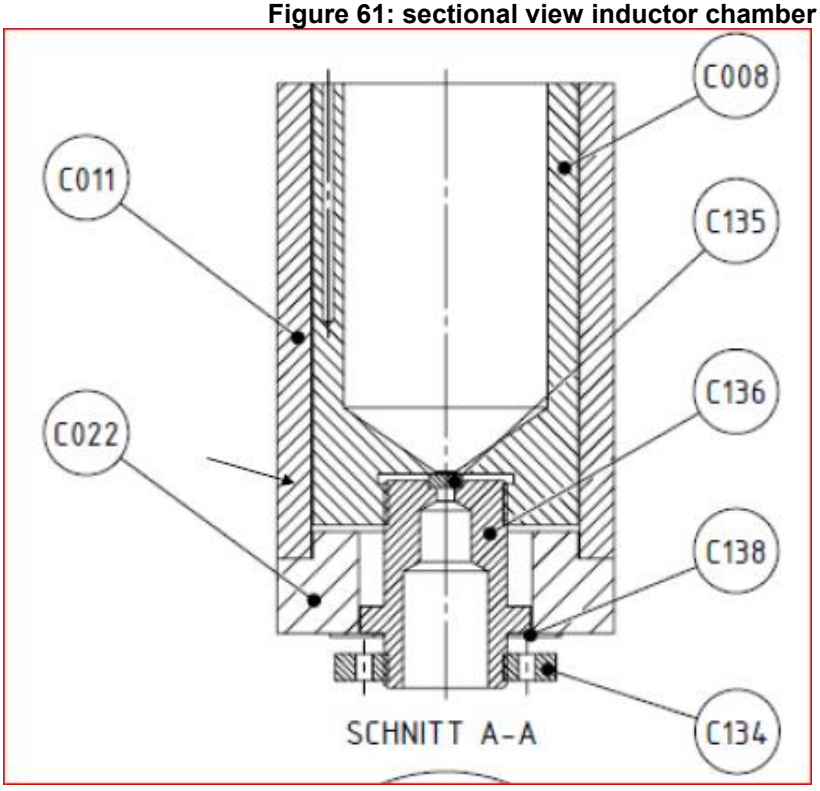
GU500

Figure 60: sectional view crucible chamber



GU500 Micro

Figure 61: sectional view inductor chamber GU500 micro



10.6 Consumables and replacement parts

INDUTHERM used machine-specific spare parts and consumables lists with all the relevant information for your machine.

You can find this list on the following page.

The part number of the consumables list is composed as follows:

- G (for basic equipment).
- The next 5 digits are the machine number.
- The following combination of letters referred to the application (see below).
- The last two digits are of the Manufacturing Index, beginning with _00.

An example: G13120_VC_00. Here is a list of consumable parts Machine no. 13120, furnishings as tilting furnace, Delivery Index 00th.

On request, we can maintain a current list as a PDF document to send you any time. If now a consumable or spare part by a new and better one have been replaced, the index number so changes ascending at the end of the item number, in this case to G13120_VC_01. This list replaces thus the elderly with the index _00. This should mean that you can always access the latest consumables and spare parts for your machine.

Should your machine be equipped with options such as sintering or vacuum pressure casting, there are options for these separate consumables and spare parts lists:

G13120_VC_00 All parts for vacuum casting
G13120_GR_00 All parts for vacuum pressure casting

For ordering of spare parts and consumables, please contact your dealer or our order acceptance under the

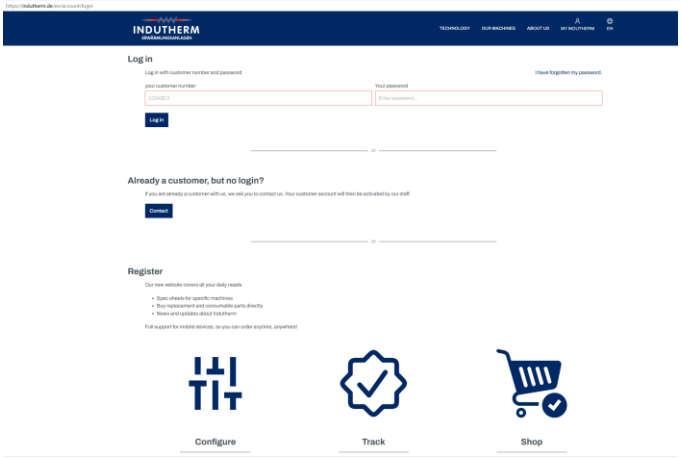
Phone number: +49 7203 9218-40.

10.7 Error and warning messages

Software-Documentation starts at next pages. The label of the bilingual documentation is “generator_documentation_800000xxx_customer_DM_F_PM_Gen.pdf”.

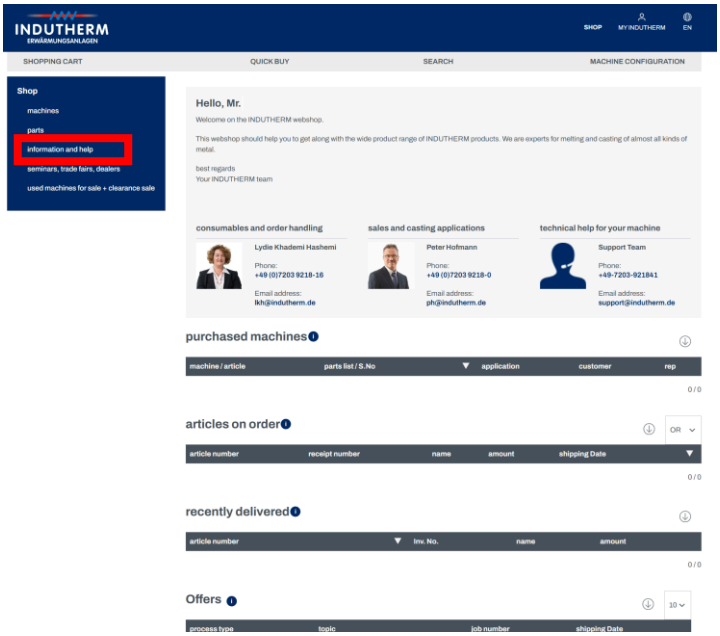
Please note: At our website
https://indutherm.de/account/login
you can get practical help for troubleshooting.

Figure 62: contact form Webshop



Until you can enjoy the advantages of the Webshop you have to apply for an access. Therefore please register. With mentioning the machine number you’ll get access to Webshop content.

Figure 63: 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”.