User Manual

Immersion heaters for aluminium



This document is an addition to the ATHERM general terms and conditions and its products.
It contains the mandatory safety instructions to prevent any injury to users.
Every customer must ensure that all immersion heater users are advised and trained on this user manual before any transport, use, installation or maintenance.
In case of doubt, the customer should contact ATHERM or its retailer for further explanations.

Important

Before installing and commissioning the equipment, please read this manual carefully the whole way through - it contains use and safety instructions.

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1 General recommendations

This document is specific to the use of ATHERM immersion heaters in liquid aluminium, for all lengths and with sheath diameters ø28mm, ø32mm, ø36mm, Ø40mm and ø55mm. It sets out the recommendations and rules to be followed for products optimum use.

Read this manual carefully and comply with the standards, safety instructions and directives in force for national accident prevention. This manual is an integral part of the equipment. It must be given to the fitter and remain available for users throughout the service life of the equipment.

1.1 Warnings

Warnings are indicated in this manual as follows:



HAZARD

• A hazardous situation exists. Failure to comply with instructions will cause death or serious injury.



CAUTION

• A hazardous situation exists. Failure to comply with instructions may cause serious injury.

RECOMMENDATION

• Failure to comply with given instructions can result in material damage to the immersion heater.

1.2 Symbols used

✓ Prior conditions that must be met.

→ Operations to be performed (one stage).

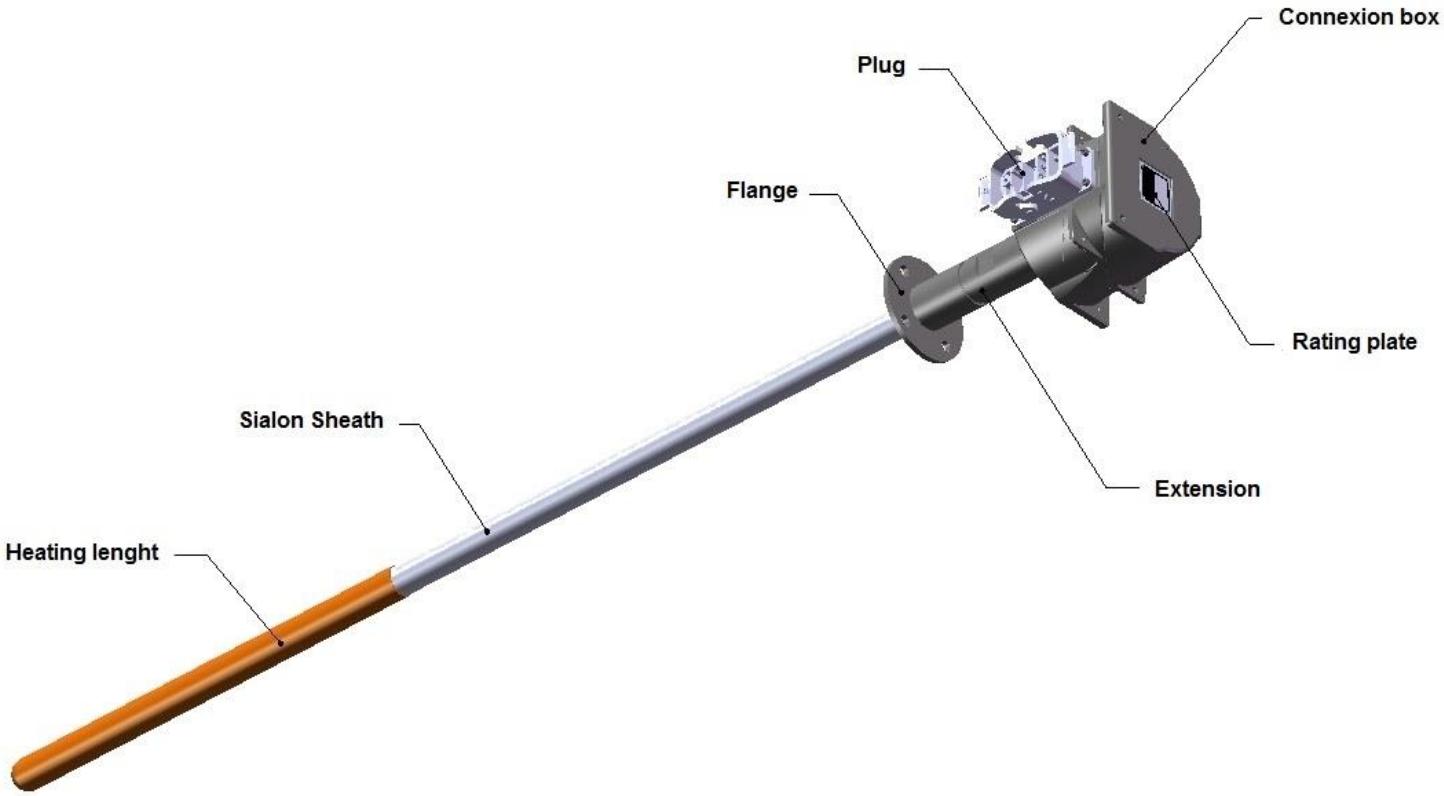
1) The first stage of an operation to be carried out. The next operations to be carried out are numbered in order.

1.3 Standards and directives

ATHERM immersion heaters meet CE requirements.

2 Product description

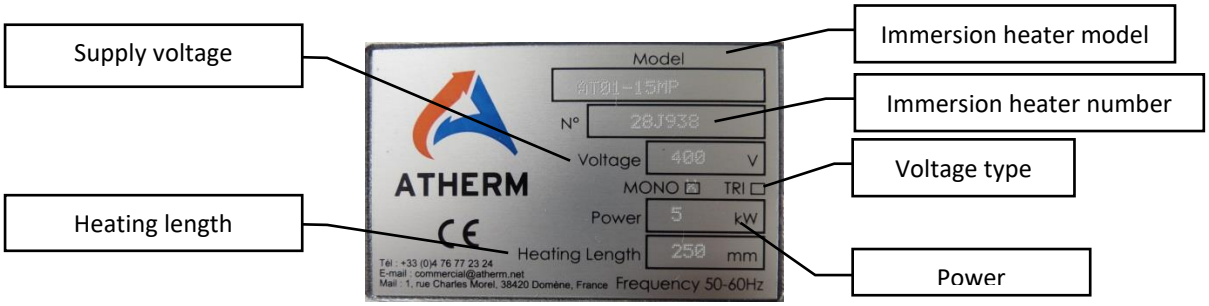
2.1 Constitution of the immersion heater



An immersion heater is made up of the following components:

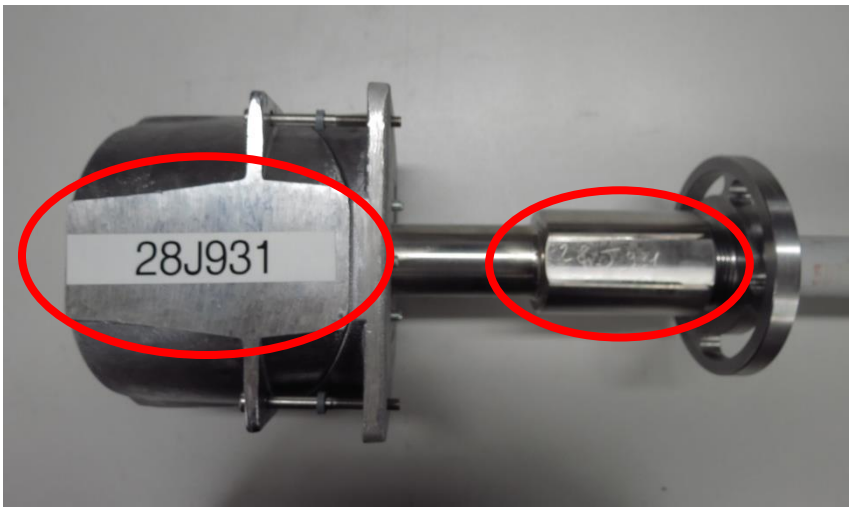
- A Sialon-type ceramic sheath
  - A heating length
    - Heating resistive wires (internal)
  - A non-heating length: energy carriers
  - An internal thermal conductive & electrical insulation compound
  - An internal safety thermocouple type K with connection to the box
- A Flange.
- A Steel extension
- A Connection box
  - An electrical connection system (quick plug or direct wires connection)
  - An internal connection system
  - An identification plate

Description of the Identification plate:



Position of the identification number:

The identification is made on the immersion heater extension and noted on a label stuck to the connection box.



2.2 Typical applications

Immersion heaters are usually used for holding and heating up liquid aluminium, zinc or magnesium in furnaces and ladles by direct immersion.

Among other things, they bring 100% efficiency, a precise temperature control, a good uniform bath temperature and help to preserve the quality of the aluminium.

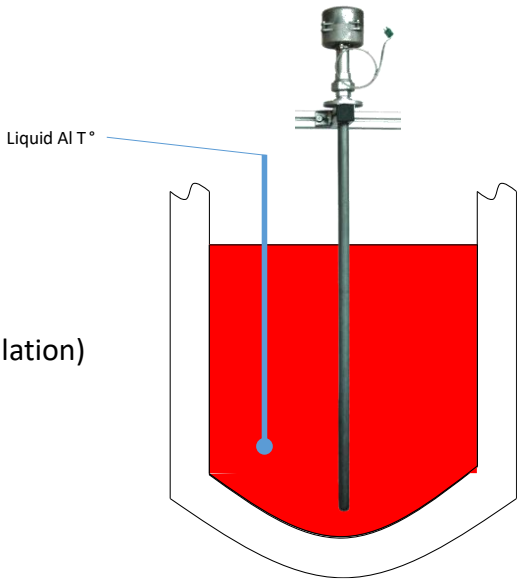
They can be used vertically, horizontally or tilted.

The heating length must be completely immersed while heating.

In some others cases, they can also be used for non-ferrous metals melting (consult us).

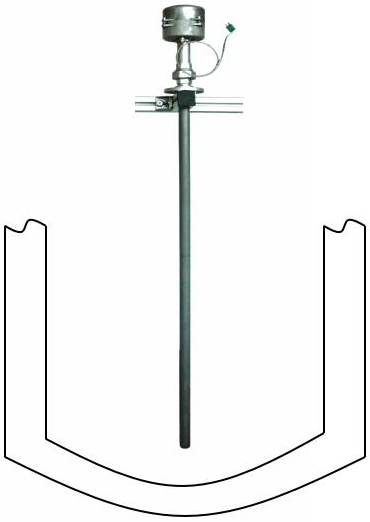
Maintaining temperature of aluminium

- Power regulated by cabinet
- Internal temperature < 980°C
- Liquid Al T° target



Dynamic heating of aluminium

- Power regulated by cabinet
- Internal temperature < 980°C
- Up to 85°C/h increasing (depending on installation)
- Liquid Al T° target

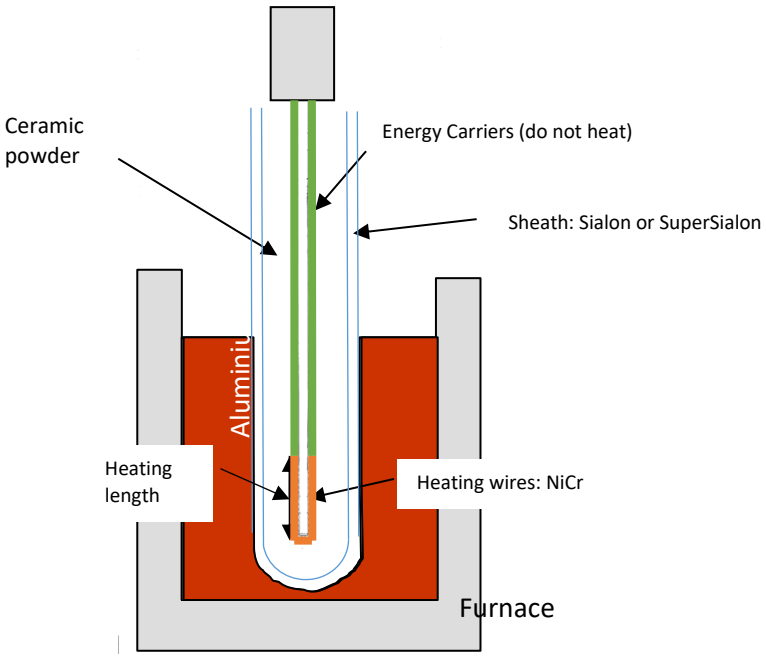


Preheating of an empty furnace or ladle

- Reduced power regulated by cabinet
- Internal temperature < 980°C

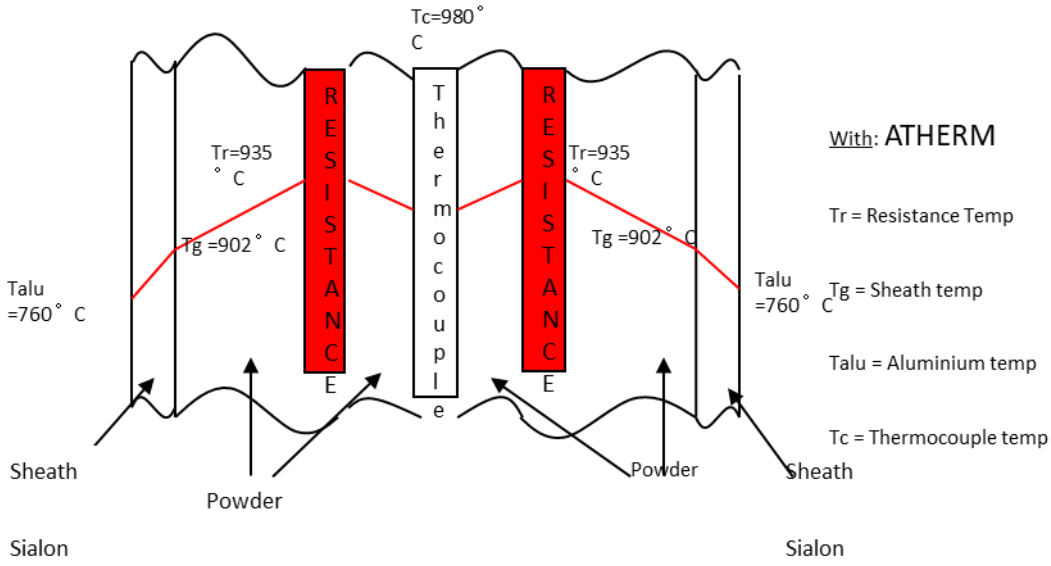
2.3 How it works

Power is generated by transformation of electricity in heat while going through resistive wires



ATHERM heaters work by internal CONDUCTION. Inside liquid metal, heat is transported by conduction & convection.

Immersion heater internal temperature profile (example):

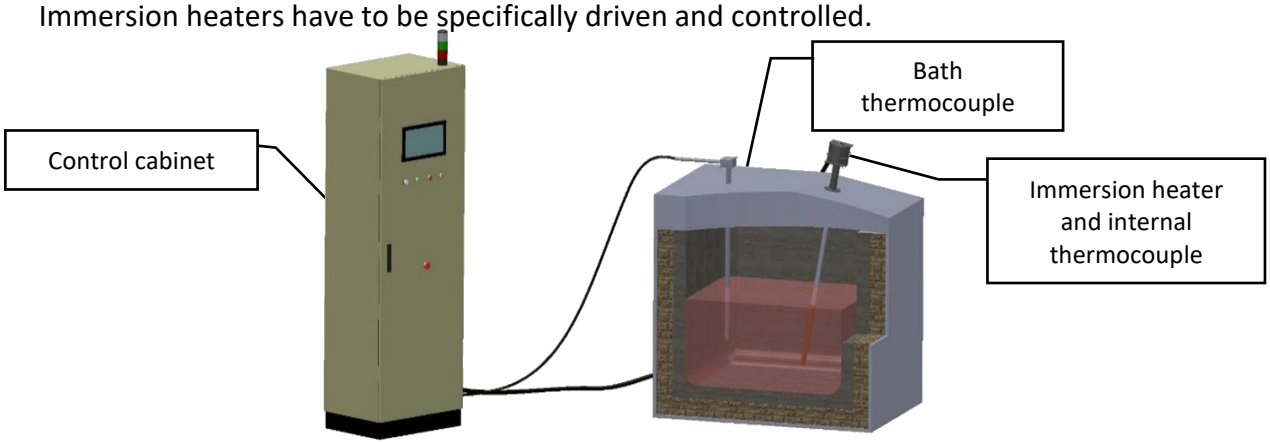


- Internal thermocouple T° is almost same as resistances T°
- Delta T° between internal T° and liquid aluminium T° is between 150 & 200°C (depending on the Alloy and convection movements in liquid aluminium)

3 General recommendations

3.1 Piloting and Control, overview

Immersion heaters have to be specifically driven and controlled.



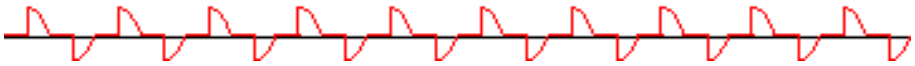
The control cabinet must be able to adjust the power of any immersion heater(s) installed in the furnace. The setpoint temperature is checked with the bath thermocouple.

The power distributed to the immersion heaters is modulated, according to the bath thermocouple temperature value.

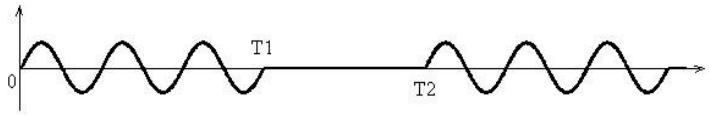
The internal immersion heater thermocouple is a safety device that prevents the immersion heater from being overheated. It is used for safety and for preheating regulation. It is mandatory that the value of this safety temperature is set at 550°C max. (1020°F) for preheating and set at 980°C (1796°F) max in working conditions.

RECOMMENDATION

The immersion heater supply power is ideally controlled by thyristors and PID. Control is via phase angle:



Or by wave train.



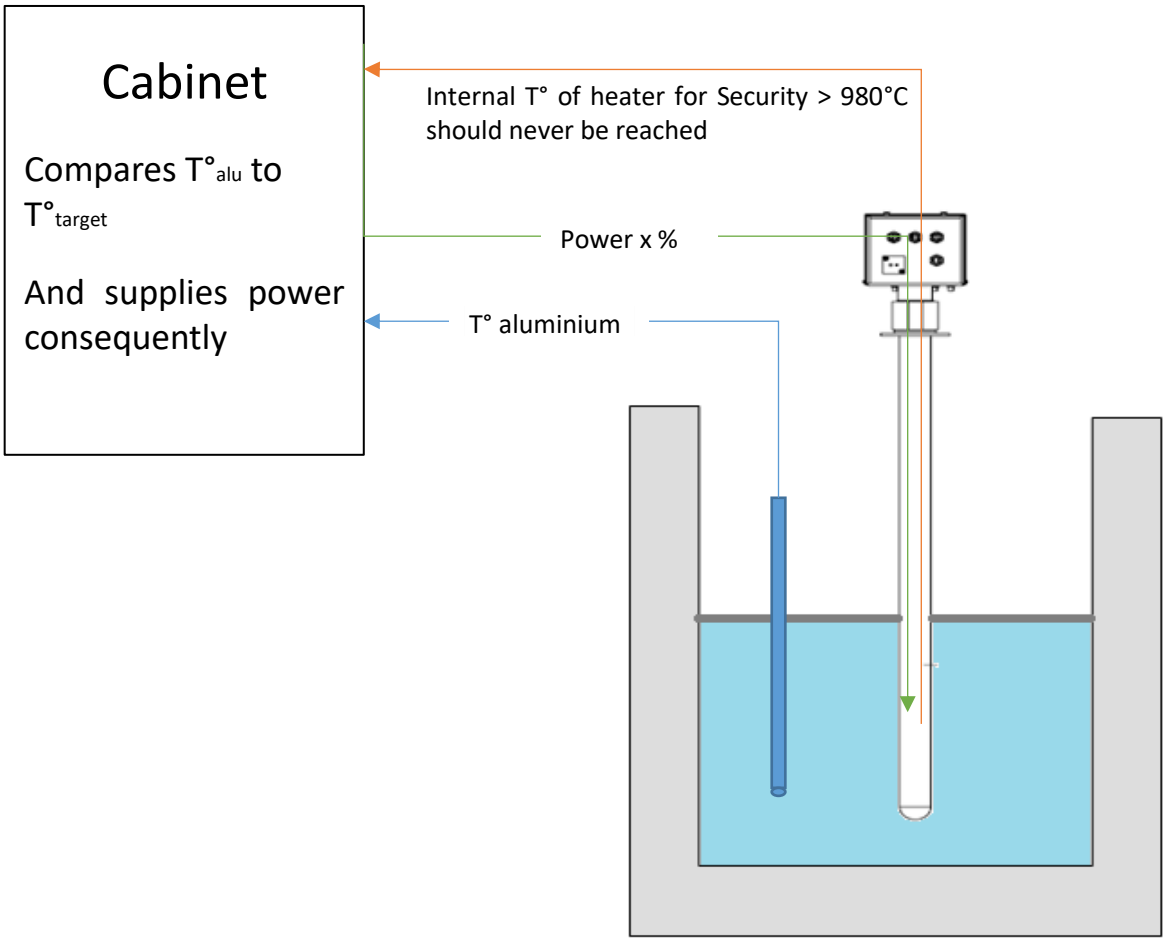
"On/Off" type control processes should normally be avoided as this type of control reduces the immersion heater service life time.

The control cabinet should therefore include:

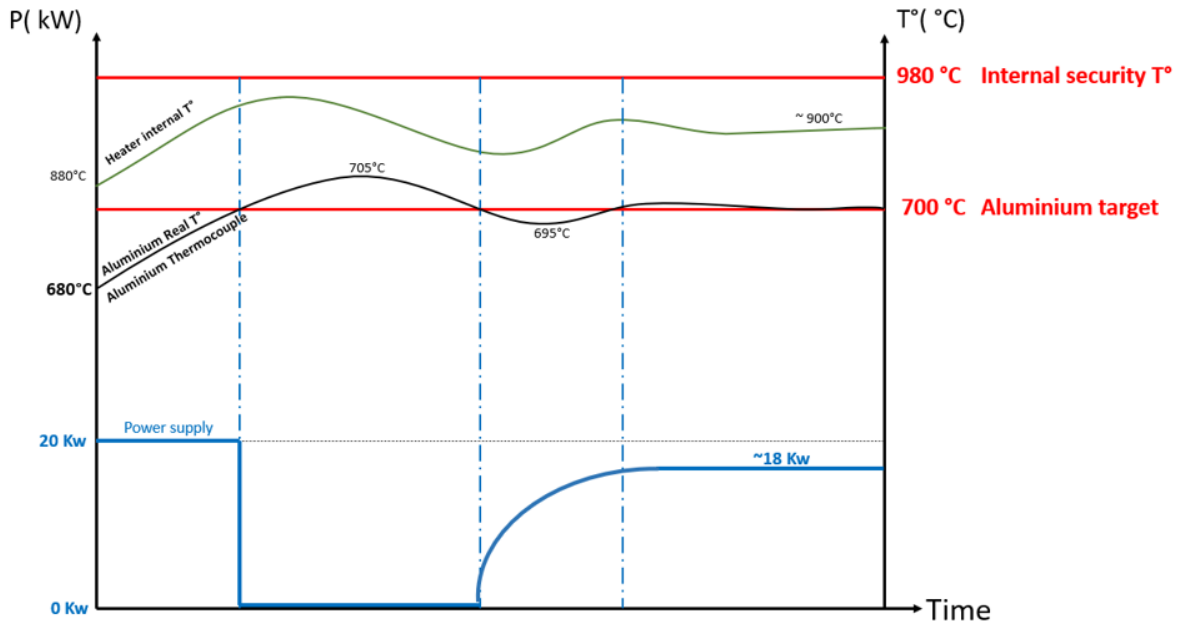
✓ A power regulator with setpoint display
✓ A phase angle or wave train control
✓ A safety device linked to the internal immersion heater thermocouple, set to 980°C (1796°F)
✓ A check that the immersion heater is actually in the bath
✓ A check on the bath level.

3.2 Piloting and Control, heating and regulation

- Start to regulate only when heater heating length is totally immersed in liquid Aluminium
- Internal thermocouple is used for safety: switch off when internal T° reach 980°C
- PID parameters need to be adjusted to avoid any on/off regulation when internal T° reaches 980°C



Example of good regulation curve (for example 20kW nominal power heater)

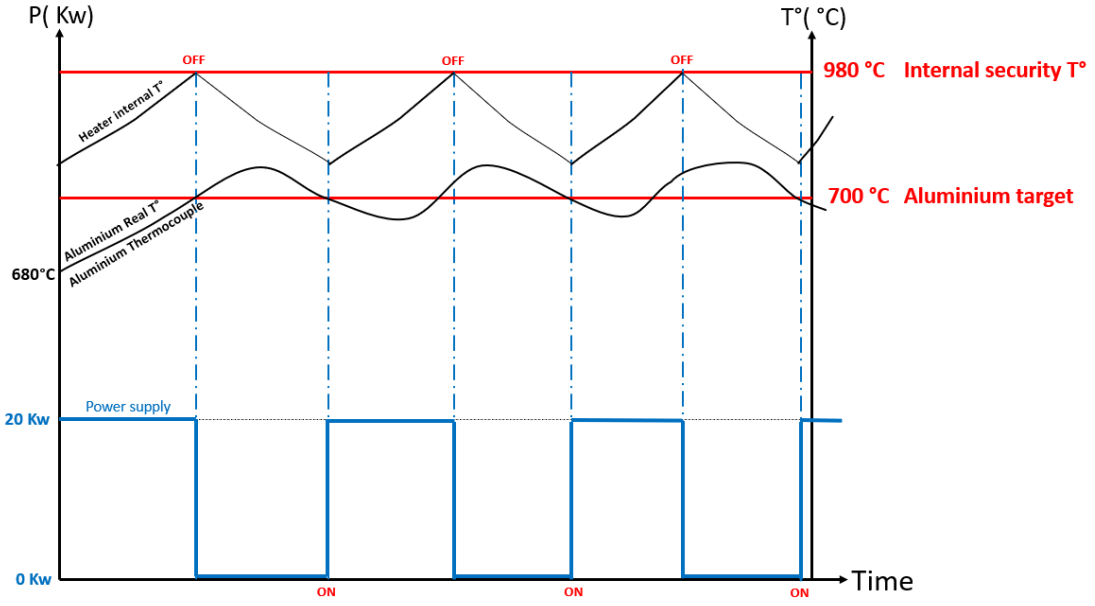


Figures are only there for example, not to be compared with real situation Temperatures

Example of bad regulation curve:

Power switch off each time heater internal temperature reaches Security T° ==> creating a On/Off phenomenon even when PID is used for regulation ==> need to adjust PID parameters.

On / Off style regulation drastically reduce life time (stresses on internal stuff: resistances, energy carriers by shrinkage-expansion cycles then breakage)



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3.3 Power supply

The immersion heaters normally have a power supply of 230 V/380 V/400/440 volts, single-phase or three-phase (refer to us for other voltages).

HAZARD	
Electrical risk	• Have the immersion heater connected and commissioned by a certified electrician. • The user must comply with the rules in force and standards relating to the installation of electrical equipment. • The immersion heater has to be connected to the installation's ground as well as the bath. • It is absolutely prohibited to handle the immersion heaters when they are working.

3.4 Storage and handling

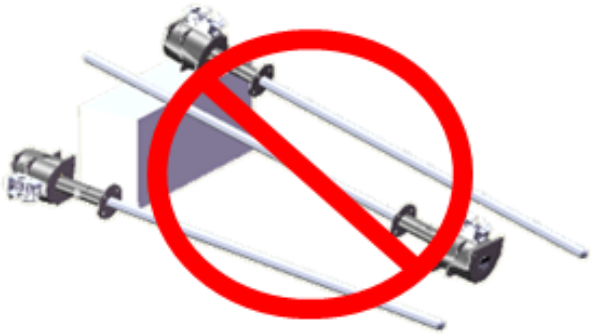
The immersion heaters are delivered in a specific box or crate.

They are packaged individually in sealed vacuum packs that must be opened when the immersion heater is commissioned. This vacuum packaging avoids any absorption of moisture that could damage the immersion heater.

Immersion heaters should preferably be stored in a dry area. Once stored for six months, and despite the protection, it is advised to dry the immersion heaters, with an oven set to 100°C (212°F) or by placing them on the lid (200°C / 392°F) for twelve hours.

Shocks and mechanical collisions between immersion heaters must be avoided. It is essential to store immersion heaters on appropriate supports.





Immersion heaters must be handled carefully and any mechanical shock on the sheath must be prevented at all costs.



HAZARD	
• It is strictly prohibited to handle the immersion heaters when they are working.	
CAUTION	
Risk of burning	• Insulating protection must be worn to handle immersion heaters with hot sheaths.



It is best to check the following points on a regular basis:

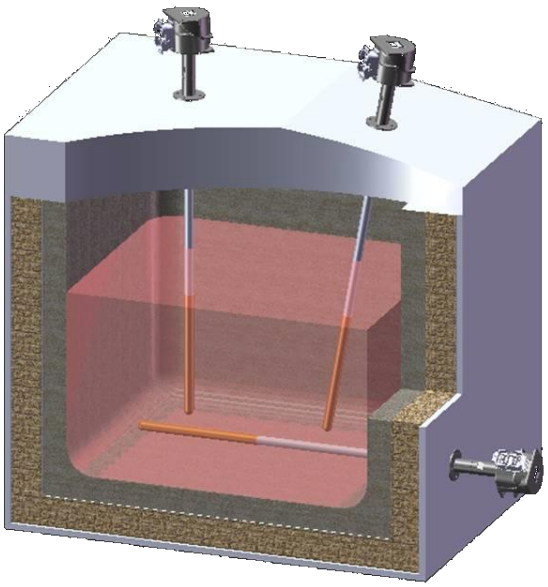
✓ Tightening of electrical connections
✓ Regulation and control equipment
✓ Internal thermocouple
✓ Set point temperature (preheating temperature less than 550°C (1022°F) and 980°C (1796°F) when immersed in the bath).
  ✓ flange not overheating (temperature less than 200°C (392°F))
  ✓ and connection head not overheating (temperature less than 120°C (248°F))
✓ Damage state of the connection head.

4 Immersion heater installation design

4.1 Installation

Immersion heater's installation design rules must be taken into account.

Immersion heaters can be implemented vertically, tilted or horizontally.



HAZARD

• It is mandatory that the heating length stays totally immersed in the liquid metal while working.

The safety distances between the immersion heaters and the furnace walls (or any solid object submerged in the furnace, for example a rotor) to be respected are set out in the diagrams and tables below:

Fig.1

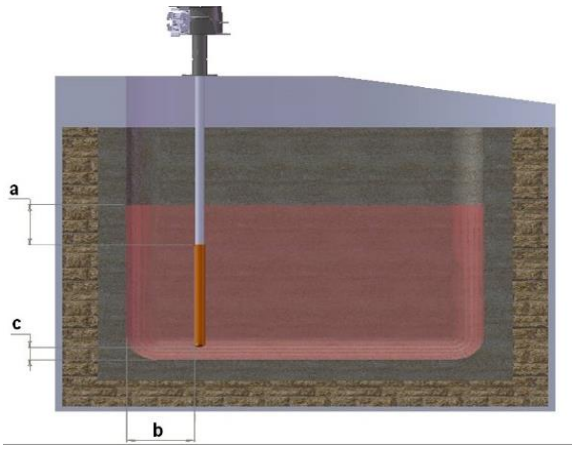


Fig.2

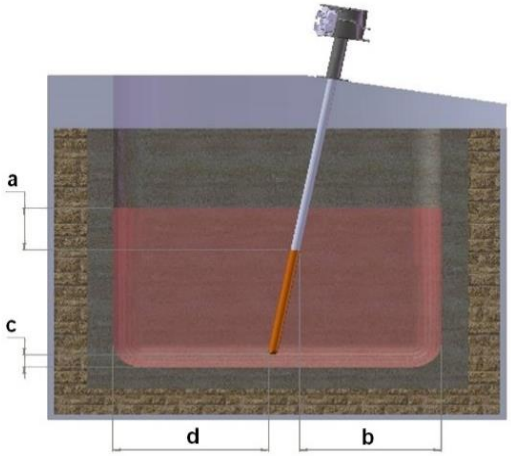
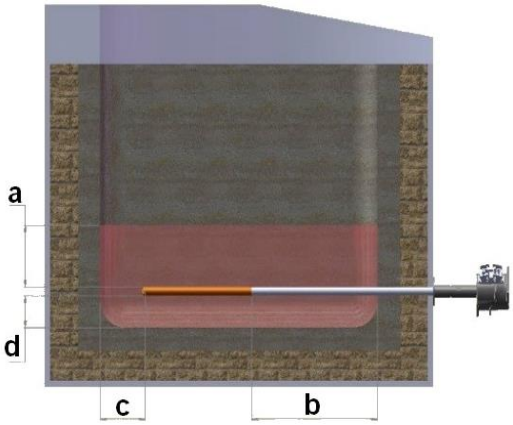


Fig.3



a: distance between the top of the heating length and the bath level.

b: distance between the external surface of sheath or the heating length and the furnace wall.

c: distance between the end of the sheath and the bottom of the tank or the walls.

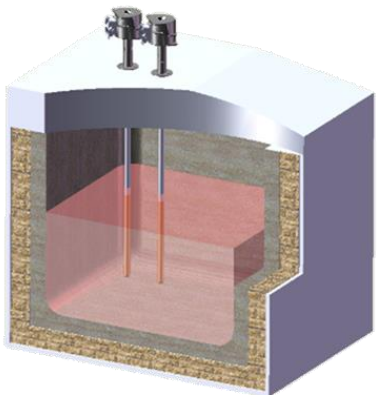
d: distance between the external surface of sheath or the heating length and the furnace wall.

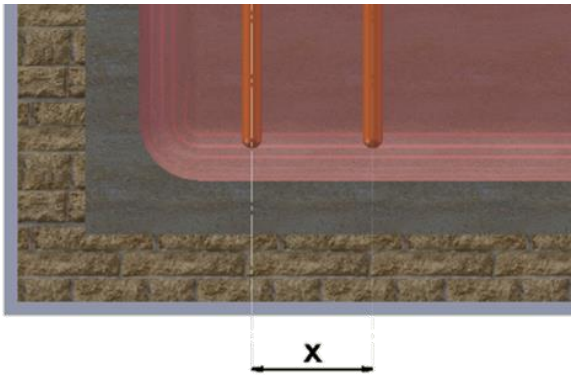
Immersion heater position	Minimum distance to be respected			
	a (mm)	b (mm)	c (mm)	d (mm)
Vertical Fig. 1	50	100	50	-
Tilted Fig. 2	50	100	50	100
Horizontal Fig. 3	100	100	50	100

Distance between two immersion heaters

In order to increase the efficiency of heaters and improve the thermal exchanges it is important to keep a minimum distance between heaters, and between heaters and furnace walls.

Installation of heaters in a room with good convection is also important.





Centre-to-centre distance X minimum

Sheaths Diameters 28mm & 32mm = 100 + immersion heater diameter.

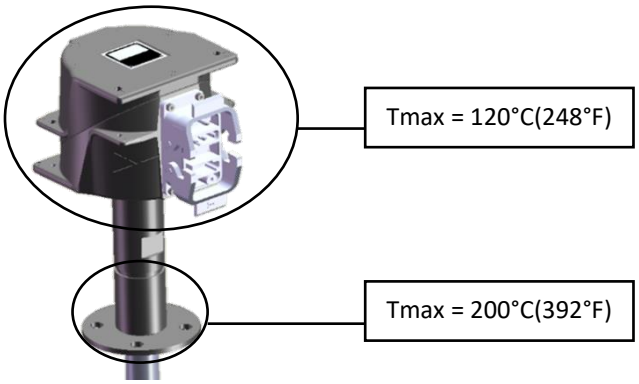
Sheaths Diameters 40mm & 55mm = 200 + immersion heater diameter.

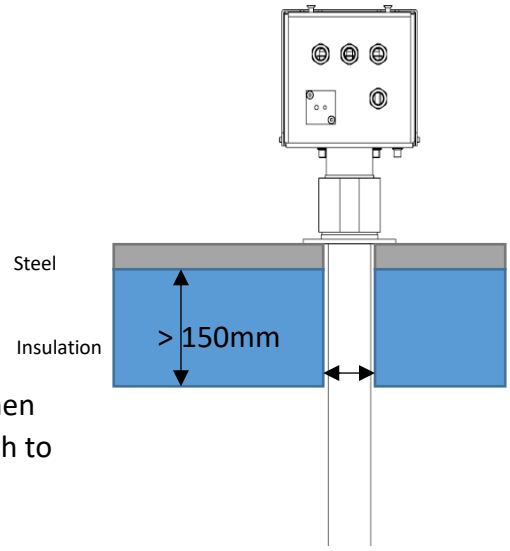
4.2 Mounting

Immersion heaters must be fixed through to the lid of the furnace or its walls.

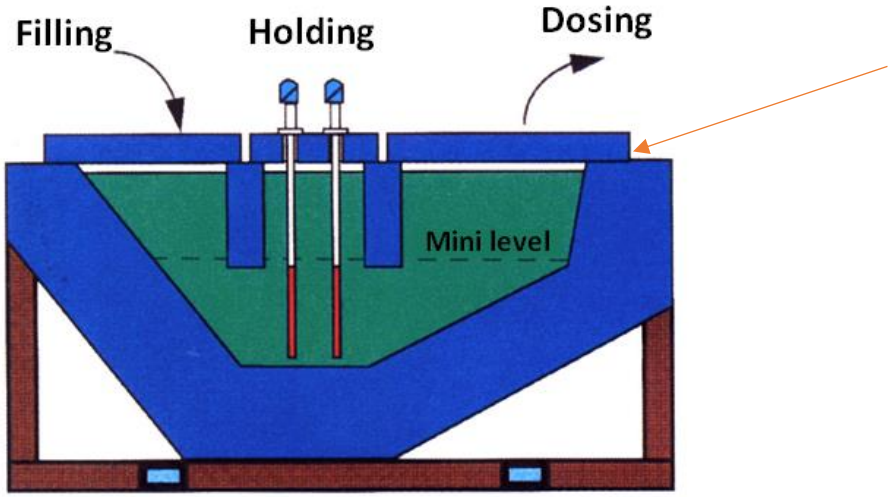


The immersion heater installation must allow compliance with the following temperatures during operation: a good thermal insulation in the furnace cover (or wall) is necessary.





In order to automatically switch Off the heaters power when opening the furnace cover, it is necessary to install a switch to detect the cover movements.



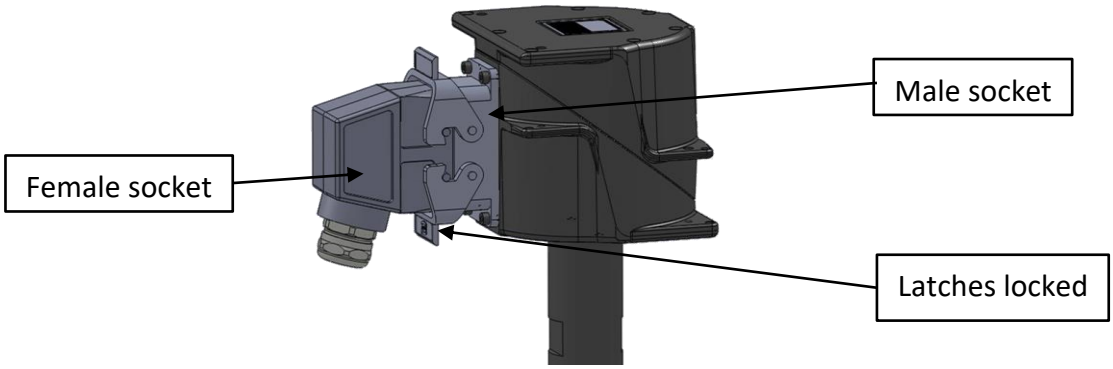
5 Connections

We offer two types of connectors:

- Quick plug, “Harting” type or equivalent
- Connection by terminal/cable lugs and cable gland fitting

5.1 Connection with quick plug

Quick plugs are usually Harting or Ilme brand as per standard EN61984. The male and female sockets are plugged together to make the connection before being locked.

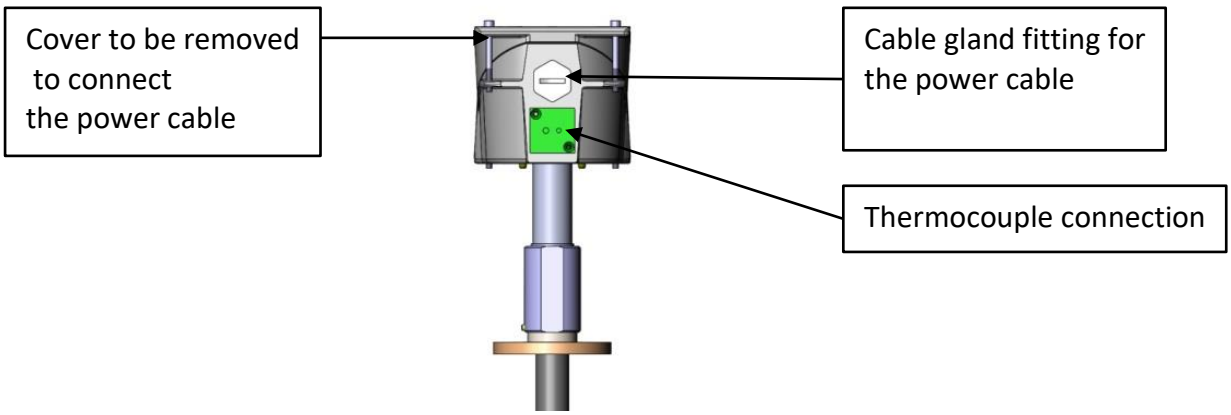


The male socket delivered fitted to the immersion heater is pre-wired and no intervention is required.

5.2 Direct connection to terminal block via cable gland fitting

Removing the head:

The head has to be removed to be able to connect to the immersion heaters through the cable gland fitting. The plastic plug delivered fitted to the head should be replaced by a gland fitting PG21 (immersion heaters ø28 and 32) or PG36 (immersion heater ø55).

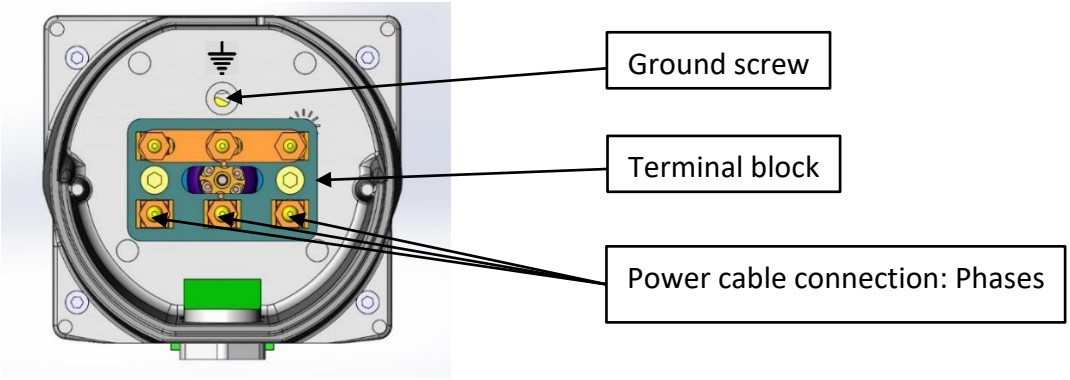


Connecting the power cable (not supplied by ATHERM):

The power cable is dimensioned based on the amperage required for the immersion heater to operate.

Thread the power cable through the cable gland fitting.

Remove the first nut from terminals U1, V1 and W1 and connect the power cable lugs. Retighten the nuts to a max. torque of 3 Nm.



Remove the ground screw and connect the ground cable. Retighten the screw to a max. torque of 3 Nm.

Thermocouple connection:

The thermocouple must be connected to the immersion heater using a thermocouple cable type K.

Connect the thermocouple cable type K to the female socket on the immersion heater.

The thermocouple cable must be connected to the control cabinet and should cut off the power to the immersion heater if the sets points are exceeded (see §6.4).

6 Heating and use in a furnace

Before use, any immersion heater stored for a long time should preferably be dried (see §3.3).

It is essential when using an immersion heater to observe the followings steps :

6.1 Preheating

CAUTION

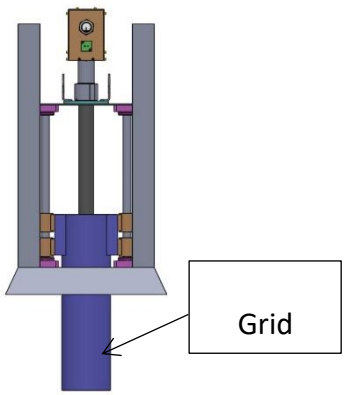
• Preheating is essential before any immersion to avoid thermal shocks on the sheath.

The immersion heater is regulated by the control cabinet during the preheating phase. The immersion heater temperature setpoint must be 550°C (1022°F). (Please refer to §3).

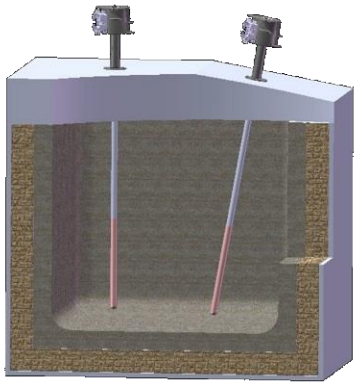
HAZARD

• The operation must be carried out in the air - a protective grid is essential - or inside an empty oven/furnace.

Preheating in the air:



or in an empty oven:



The following points must be strictly observed during this operation:

✓ The immersion heater sheath must not be in contact with anything at all.
✓ The immersion heater must be connected to the ground.
✓ The internal thermocouple must be connected to the control system.
✓ Preheating must last at least ten minutes.
✓ The power supply must be cut off before any handling operation.

Preheating helps to avoid big stress on Sialon sheath when heaters are immersed

Preheating helps to reduce delta T° between Sialon sheath and liquid aluminium before immersion

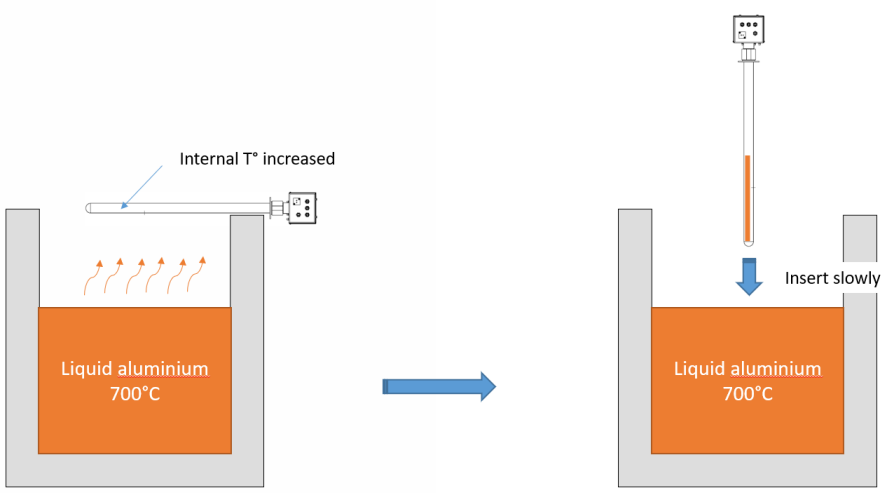
Preheating T° is approximately 350°C to 550°C, never higher than 550°C / during 5 to 10mn

How to preheat?

==> **Solution 1:** with convection above furnace

- heater power supply switched off
- put the heater above the bath, and wait until internal T° increase
- slowly insert heater in the bath
- switch on power supply

(with this type of preheating, internal temperature never reaches 550°C target).



How to preheat?

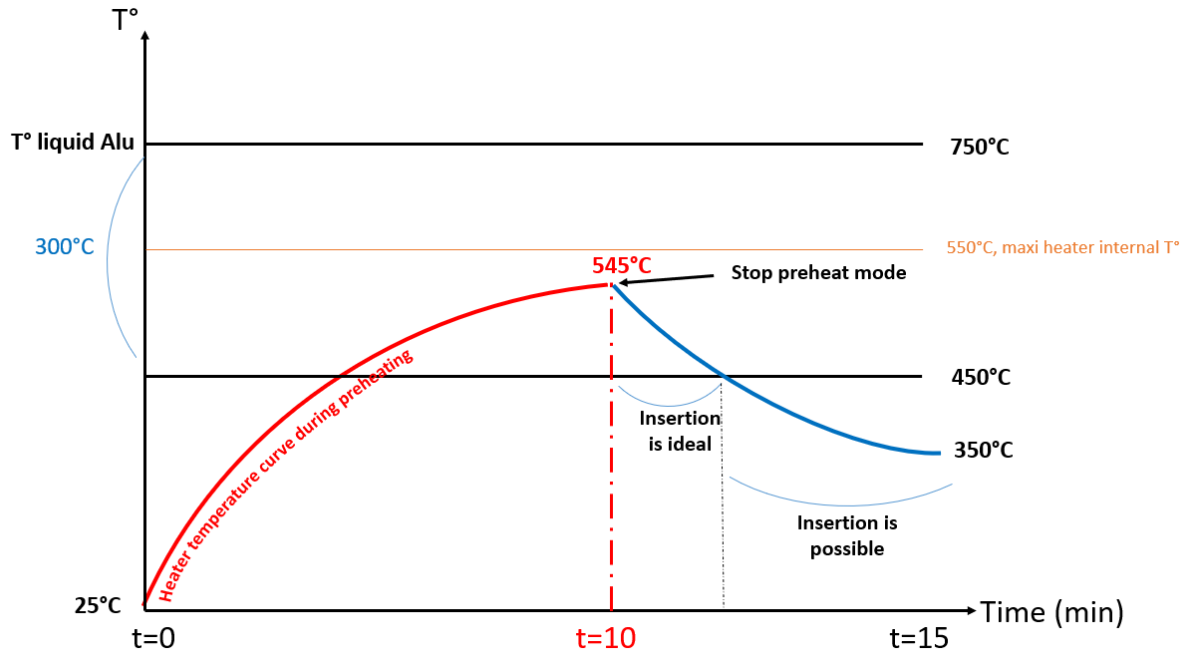
==> <u>Solution 2:</u> With piloting cabinet on preheating mode

It can be done by reduced power (best solution for safety) or by internal Thermocouple

Example of preheating:

- **#1 t = 0min ==> T°heater = 25°C**
- **#2 start preheat at 5 or 10% of nominal power**

  (to be confirmed depending on the heater power)
- **#3 t = 5min ==> T°heater = 450°C (example)**
- **#4 t = 10min ==> T°heater = 545°C (example)**
- **#5 Stop preheat mode**
- **#6 t = 15min ==> T°heater = 350°C (example)**
- **#7 Immerse slowly**



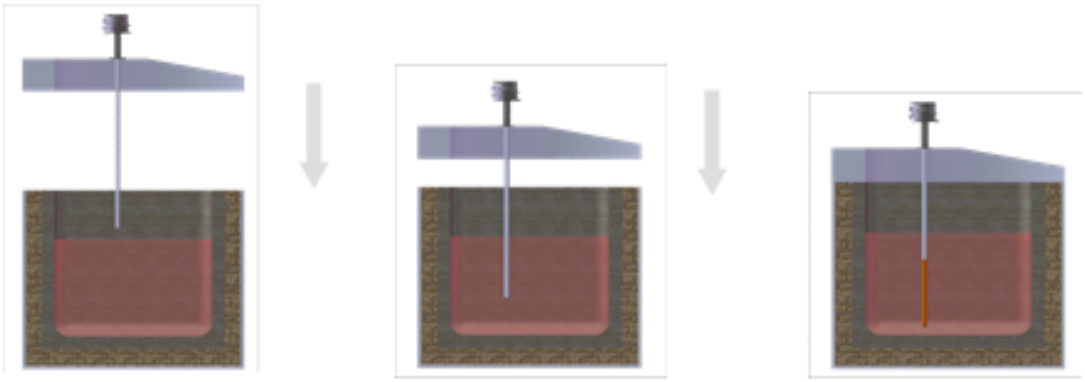
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HAZARD	
 Risk of bursting	• The internal temperature (measure with the internal thermocouple on the immersion heater) not to be exceeded when preheating is at 550°C (1022°F). The Sialon sheath's color should never become red. Any temperature runaway can cause a risk of overpressure and bursting of the immersion heater.  **Internal T° too high = risk of bursting** • When preheating takes place in the open air, a protective grid must be placed around the immersion heater. • During the preheating phase, no mechanical shock, cold thermal shock, spraying of compressed air or liquid on the immersion heater, especially the Sialon sheath, must occur. • The internal safety thermocouple must be connected to the cabinet and must not exceed 550°C (1022°F).

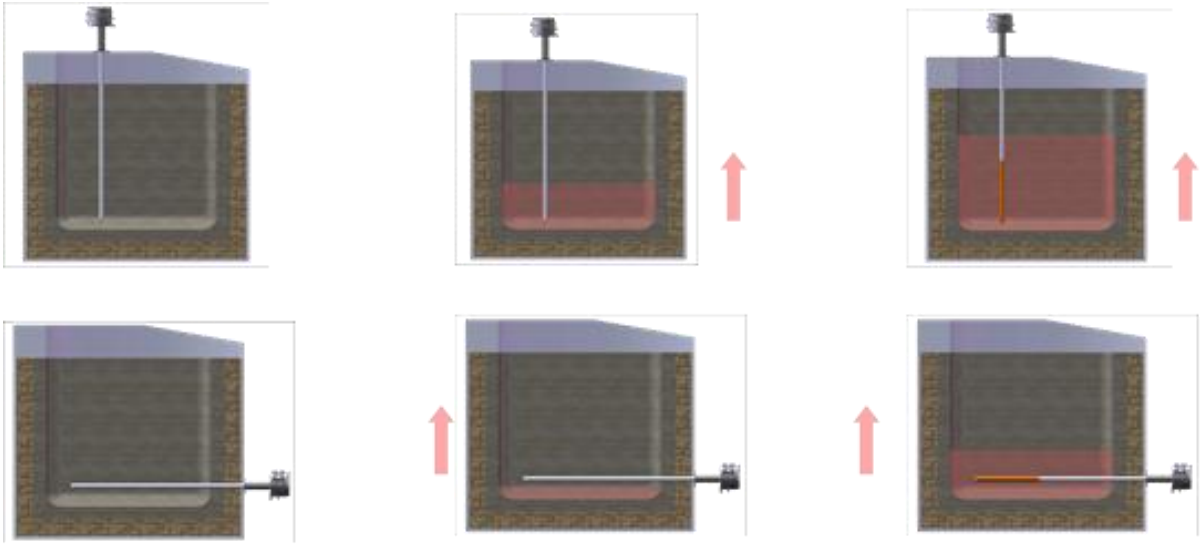
6.2 Immersion

There are two different ways for immersion:

1- Immersion in the aluminium bath at slow speed (about 30 s for total immersion) to avoid any thermo-mechanical stress on the sheath.

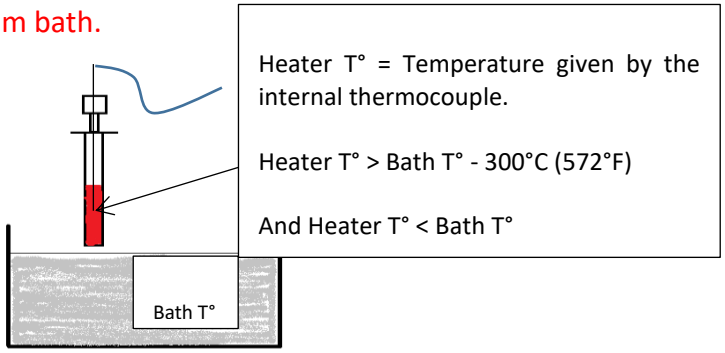


2- Filling the oven when the immersion heater is already installed in it and preheated. Filling must be gradual and without direct spraying on the immersion heater sheath.



It is mandatory to respect the following rules during immersion:

- ✓ Preheating phase completed (authorisation to plunge PLC).
- ✓ The difference in temperature between the immersion heater and the aluminium bath must never be more than 300°C (572°F).
- ✓ The temperature of the immersion heater must never be higher than the temperature of the aluminium bath.



- ✓ Power supply cut off during handling operations.
- ✓ Minimum aluminium level reached.
- ✓ Heater heating length shall be totally immersed.

During this phase, no mechanical shock, cold or hot thermal shock, spraying of compressed air or liquid on the immersion (warm) heater, especially the Sialon sheath, must occur.

After these operations have been completed, then the full power processing can start.

6.3 Heating

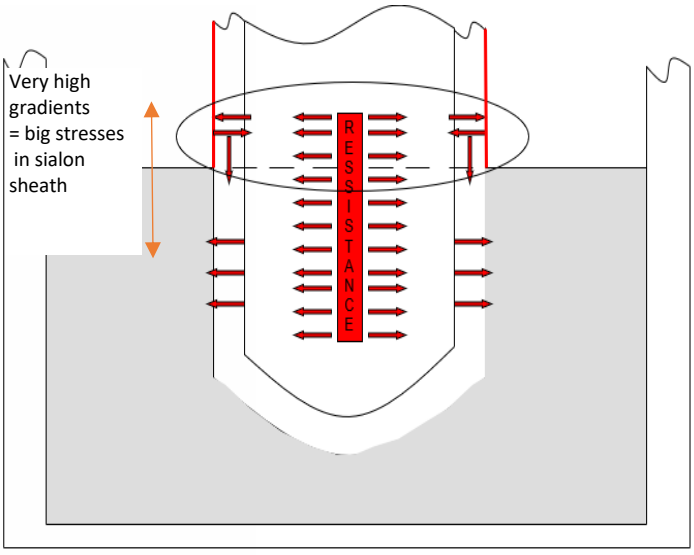
During the work phase (heating), the immersion heater is regulated by the control cabinet and the power is delivered based on the bath temperature setpoint. (please refer to §3).

HAZARD	
 Risk of bursting	• The internal temperature of the immersion heater must never be more than 980°C (1796°F). Risk of the immersion heater being damaged or even bursting. The control cabinet must therefore cut off the heating process if this value is exceeded

It is mandatory that the heating length is totally immersed when the heater is in operation.



Internal temperature increases rapidly, 20°C to 900°C in 20 seconds, and even more rapidly in part of sheath outside of aluminium.



Dewatering = part of heating length outside liquid aluminium = risk of explosion

It is absolutely mandatory to avoid any contact with the furnace walls and with solid objects introduced into the bath (aluminium ingots, NC parts).

Any immersion heater that has to be removed from the bath for cleaning or other any maintenance operations must no longer be powered during the operation.

When the immersion heaters are operating on the aluminium bath, it is mandatory to have physical protection around the heating area to avoid injury in the event of a breakage and material projection.

6.4 Reminders of temperatures to be respected

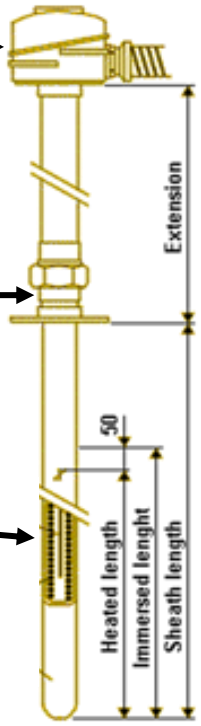
Max. temperature of the head = 120°C/248°F

Max. temperature of the flange = 200°C/392°F

Max. temperature of the internal thermocouple at the immersion heater

Preheating → **max 980°C/1022°F** in the air (for at least 10 min.)

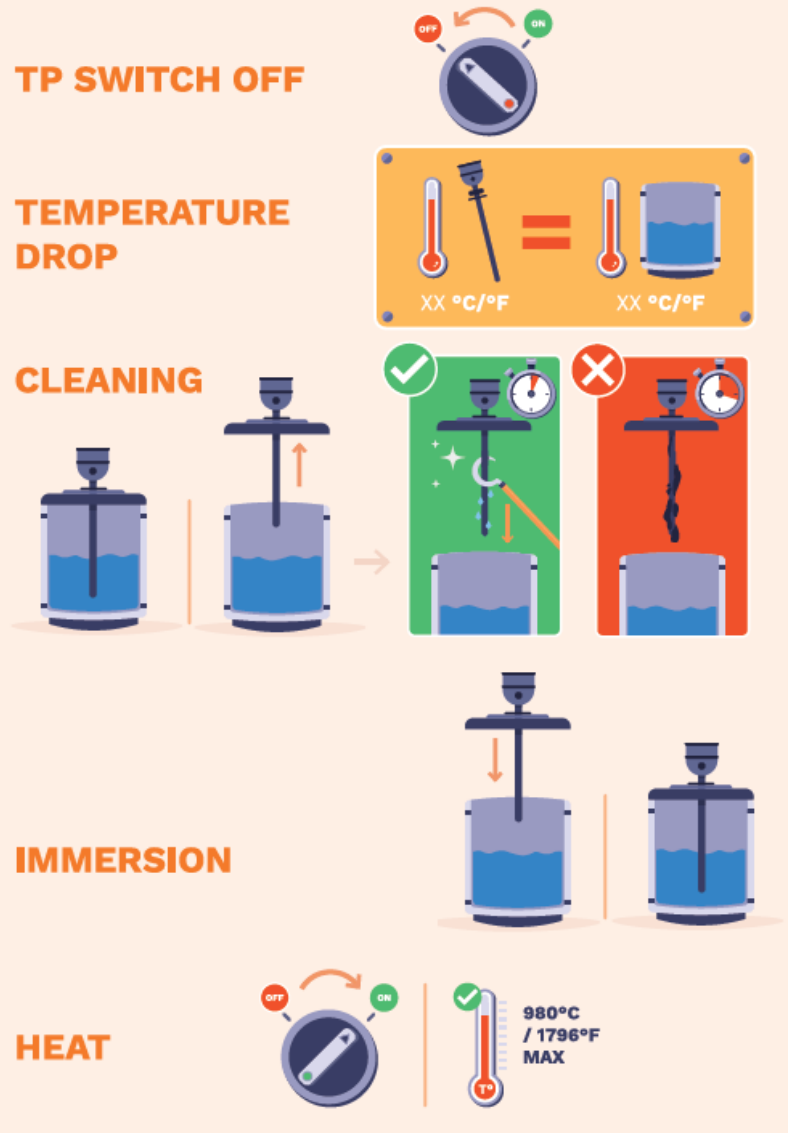
Heating → **980°C/1796 °F** in the aluminium bath



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7 Cleaning, maintenance and precautions

Before removing the heater from aluminium bath, make sure that the power is cut off and the liquid aluminium is not yet frozen before cleaning the immersion heater. The customer must ensure that the user wears all the appropriate personal protective equipment (PPE) and has been advised of the maintenance safety rules in advance.



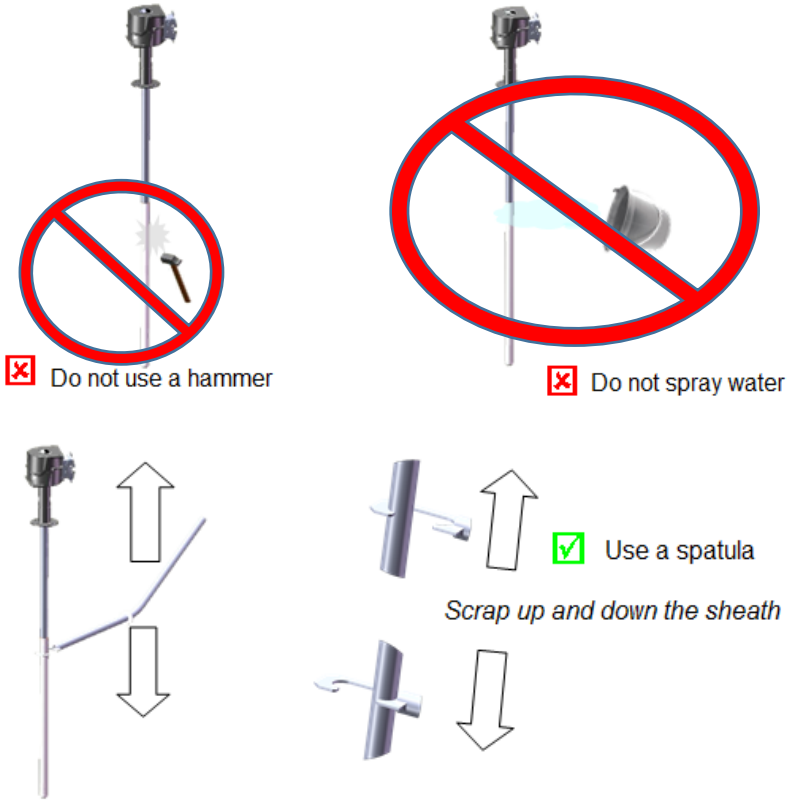
In order to increase the service life time of the equipment the sheaths have to be cleaned.

On vertical position a daily visual inspection on sheath is advised to limit the dross's deposit.

While working under horizontal position the heater has to be cleaned only when the furnace is drained.

In any case it is recommended to clean the immersion heater by "scraping" the dross's with a spatula. This must be performed with the power cut off and when the immersion heater is still hot.

✓ Avoid all mechanical shocks during this operation.
✓ It is absolutely prohibited to spray water or blow compressed air onto the sheath.
✓ The permissible thickness of aluminium on the sheath must be no more than 5 mm.
✓ The immersion heater power supply must be cut off during cleaning.

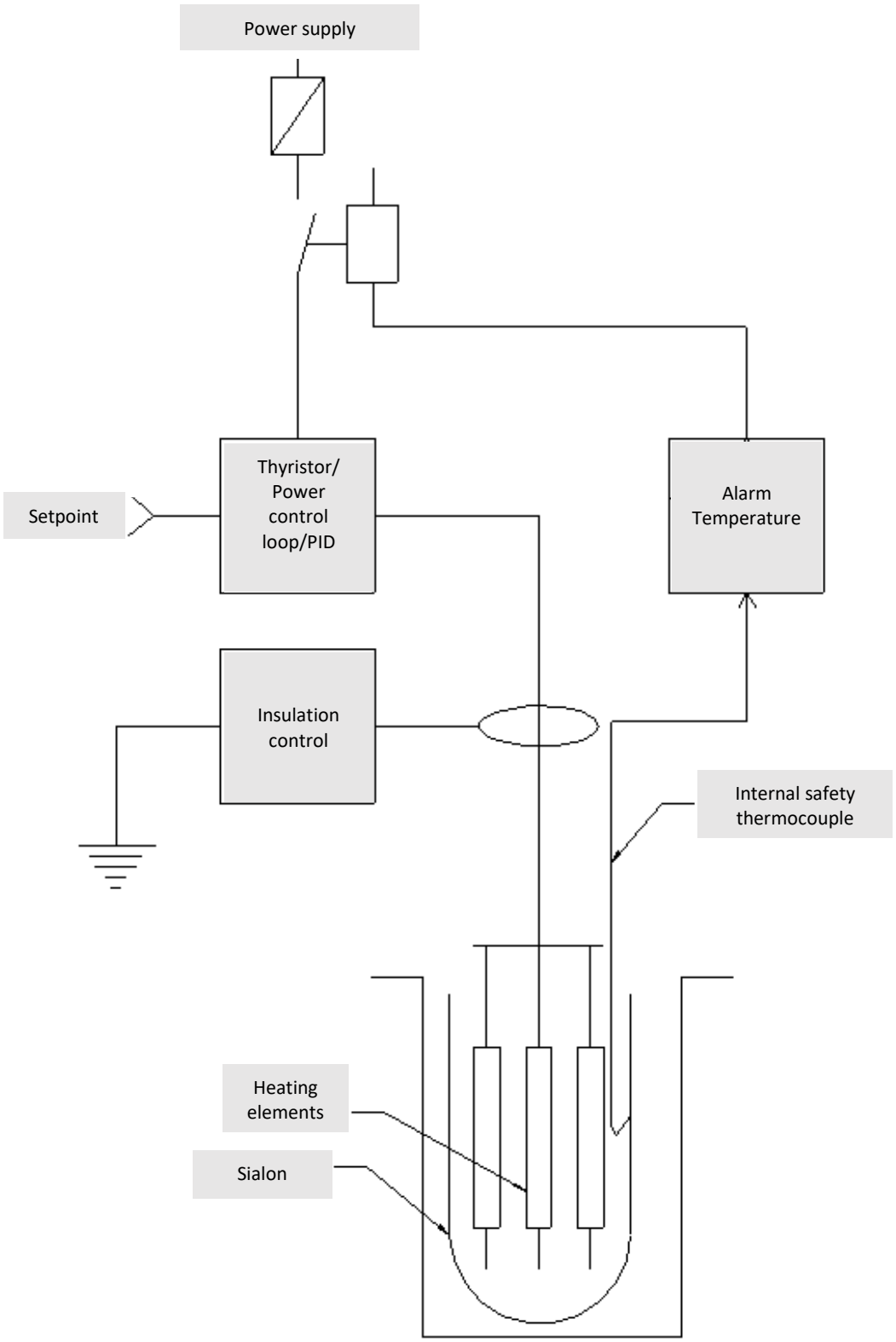


The sheath must never be subjected to cold thermal shock.

It is advisable to check the following points on a regular basis:

✓ Tightening of electrical connections
✓ Regulation and control equipment working properly
✓ Internal thermocouple working properly
✓ Sheath, flange and connection head not overheating
✓ Damage state of the connection head.

8 Connection diagram



9 Summary to help in understanding the User Manual

THIS SUMMARY IS NOT A SUBSTITUTE FOR READING THE COMPLETE USER MANUAL.

Power supply and control	Depending on model 220/240 V single-phase or 380/420/440 V three-phase	Using thyristors (phase angle or wave train)	Internal safety thermocouple connected to the control cabinet Max. internal preheating T° 550°C (1022°F) Max. internal heating T° 980°C
Handling	Mechanical shock prohibited.	Power supply cut off during handling operations.	
Storage	Long term storage > 6 months = dry before use		
Installation	Immersion heater sheath never in contact with furnace walls (> 100 mm away).	Immersion heater connected to the installation's ground.	Liquid metal bath connected to the installation's ground.
Precautions for use	before immersion: Aluminium T° -300°C (572°F) < sheath T° < aluminium T° Sheath must be preheated	Grid protection has to be used during preheating process	
	Always preheat the immersion heater before first initial immersion into the liquid metal. Max. T°C 550°C (1022°F) on internal thermocouple	Apart from during the preheating phase, the immersion heater must never be heated outside the liquid metal.	The heating length must always be immersed when the power is switched on. Max. T°C 980°C (1796°F) on internal thermocouple
	Avoid cold thermal shocks on the sheath No water, no compressed air blown on the sheath	Temperature at the connection head < 120°C (248°F).	

All ATHERM products can be adjusted to your specifications.

Contact us !

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