TECH-TRADE A·S

# Selection Guidelines for Electrical Heaters


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# Purpose of Electrical Heater

Process Electrical Heaters can serve many functions including:

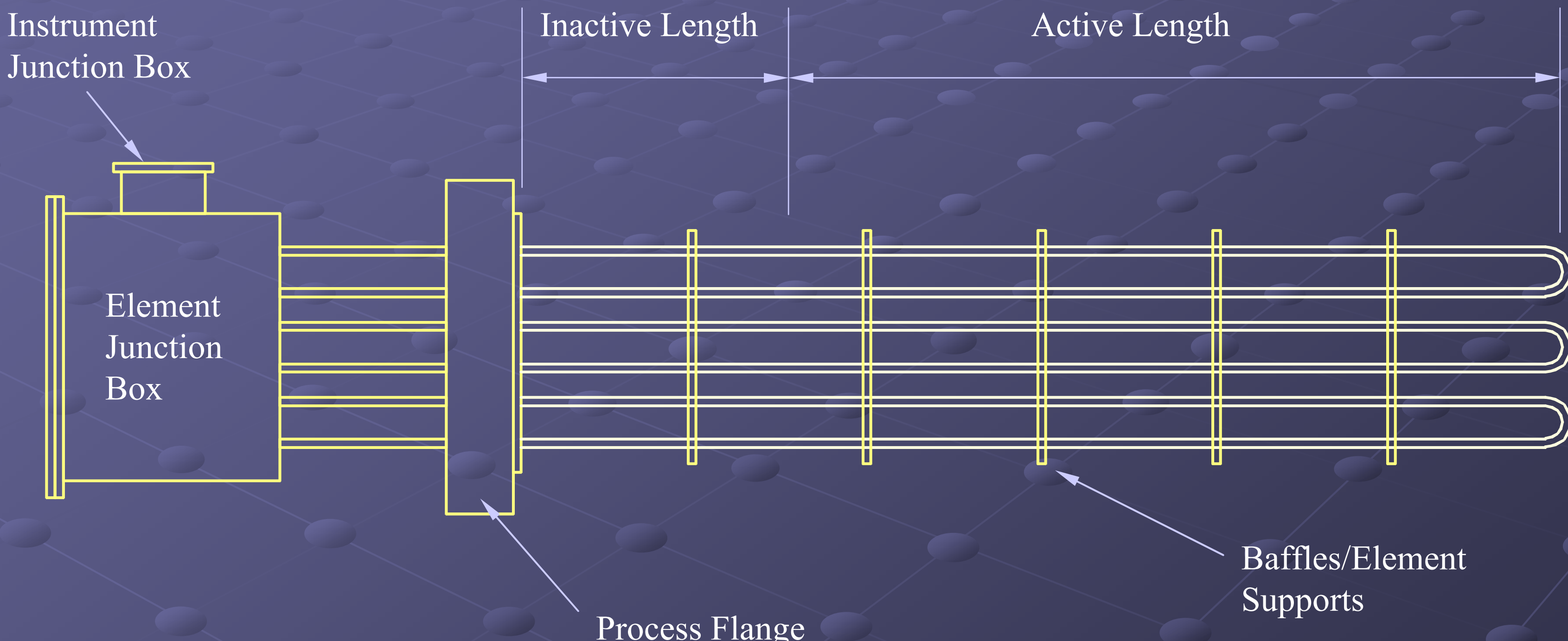
- Boiling of fluids (eg: TEG to remove water).
- Raising the temperature of gas to prevent hydrate formation (ie. Fuel Gas Heaters and Superheaters).
- Increasing the temperature of a fluid to reduce viscosity and improve separation characteristics (eg: prior to 3-phase separator).
- Providing sufficient heat in vessels to prevent freezing (eg. Immersion heaters in KO Drums)
- Heating of air in HVAC applications.

# Advantages of Electrical Heaters

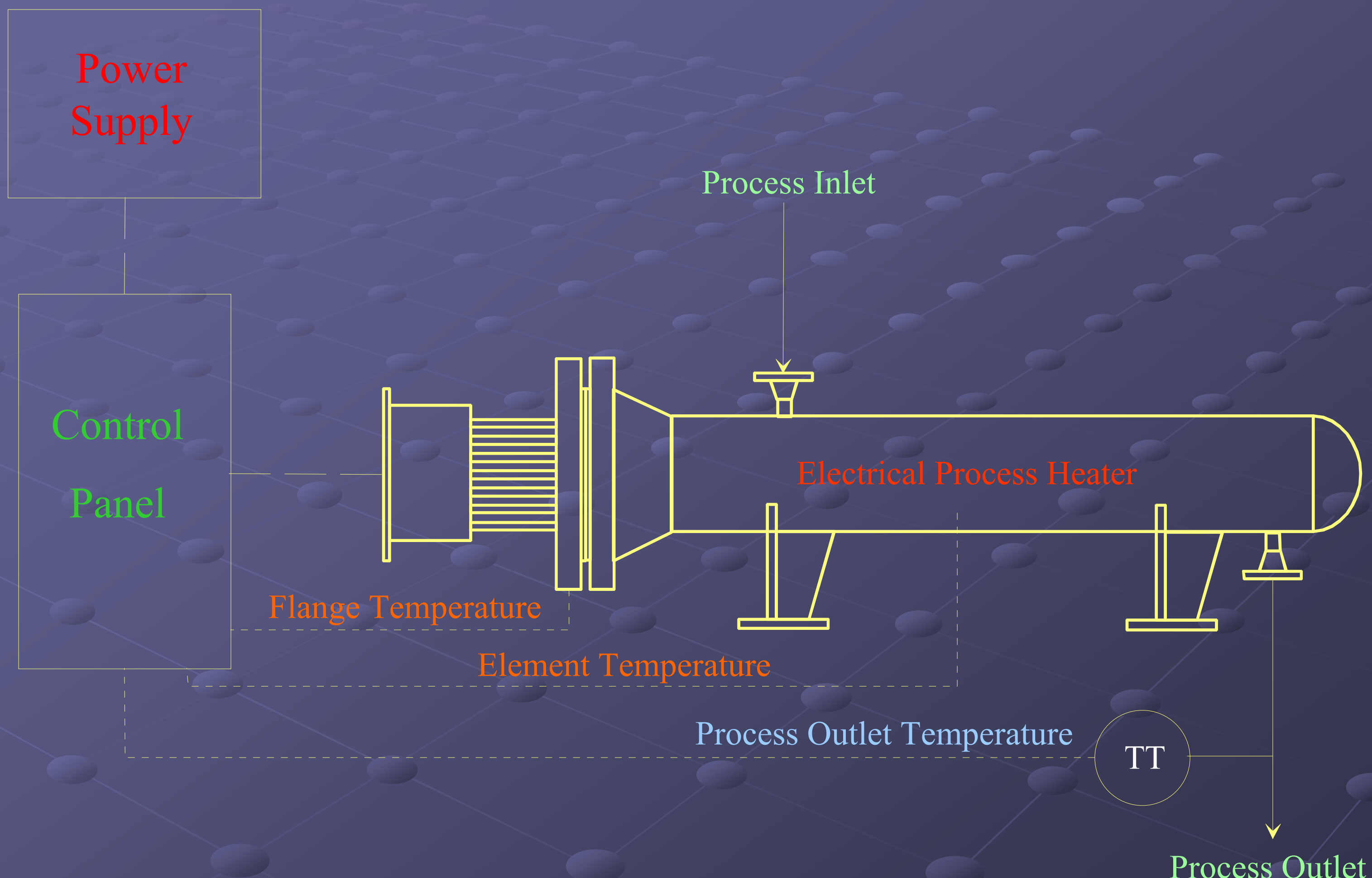
In process applications, electrical heaters provide the following advantages:

- Precise temperature control;
- Instantaneous heat from cold start-up;
- 100% turndown;
- Horizontal and compact vertical solutions;
- Minimum process hook-up;

# Construction of Electrical Heater Bundle



# Typical Electrical Heater Layout

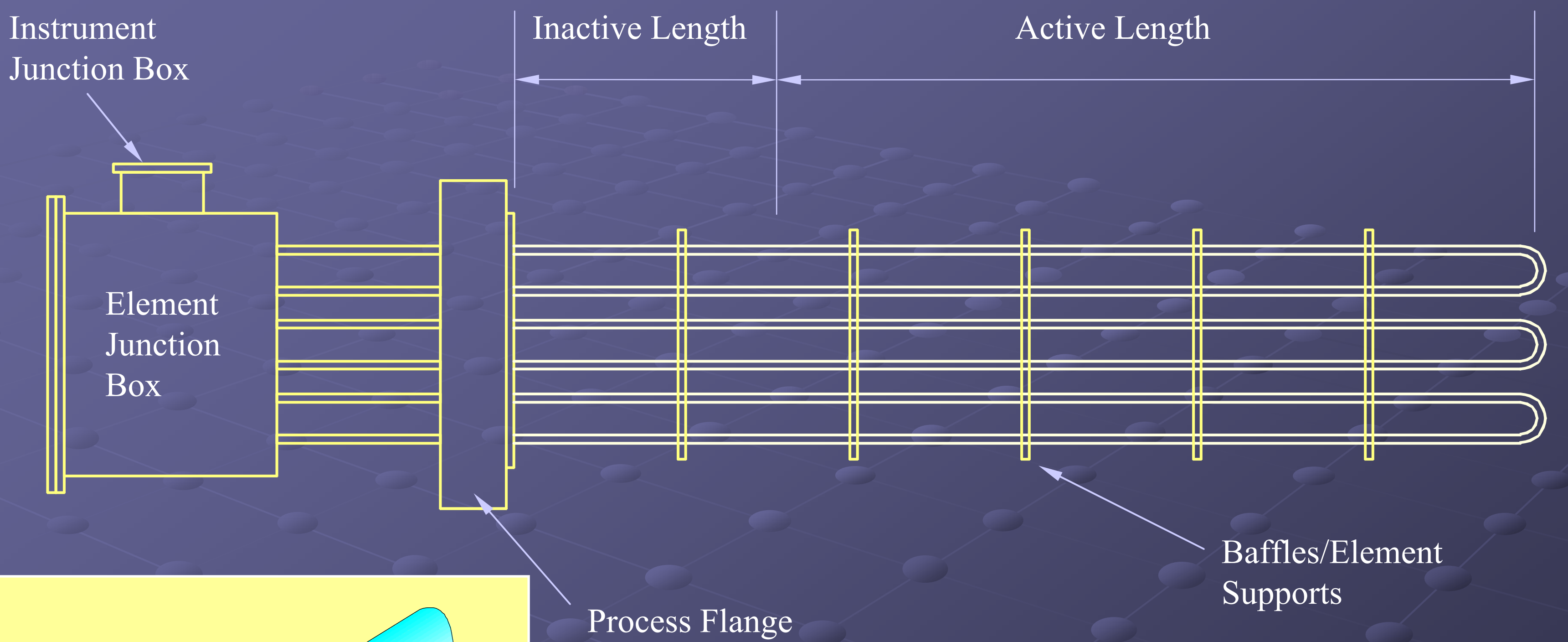


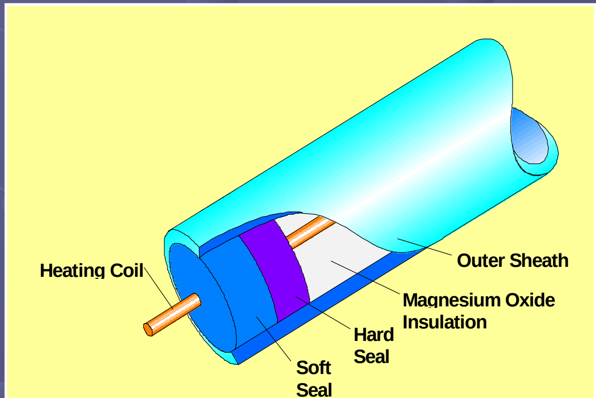
# Types of Element Design

There are two common types of heater element available for process heating:

- Hairpin Type Heater Elements
- Withdrawable Heater Elements

# Hairpin Element Design



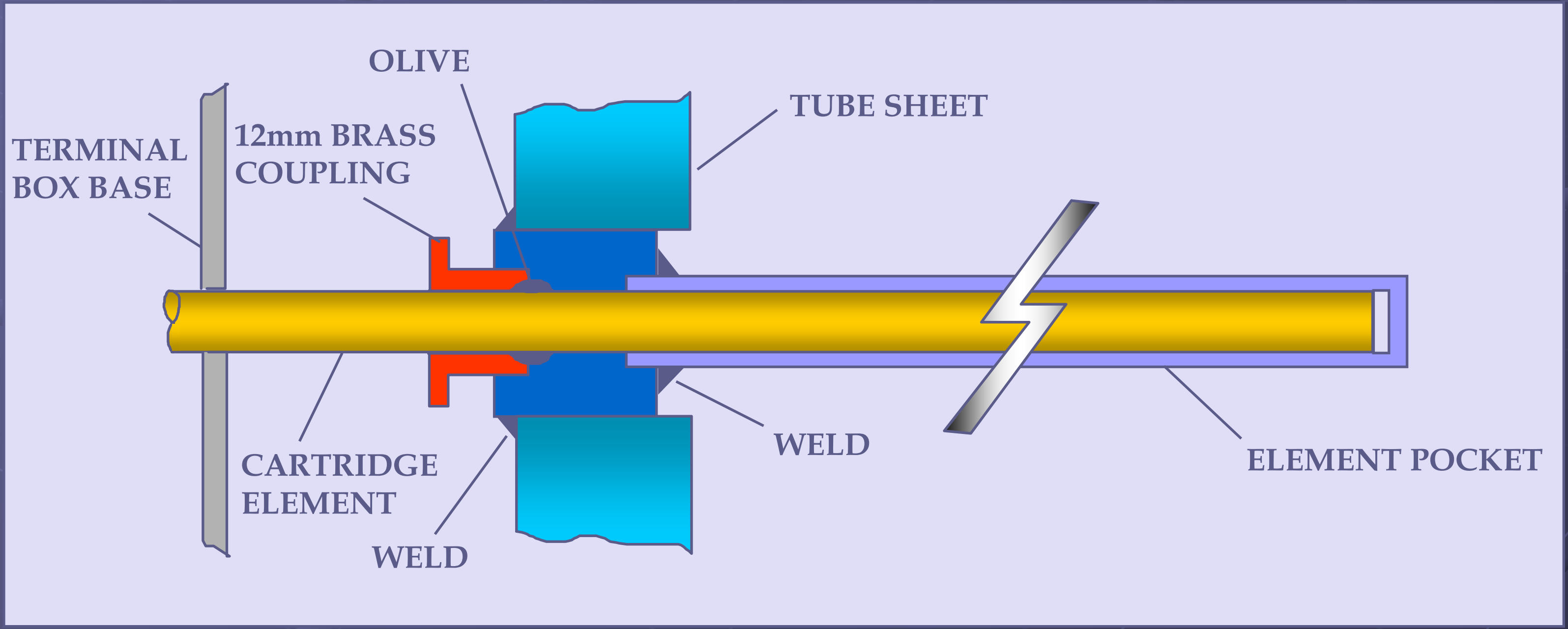




Heatex Double Epoxy Seal System

This is the most commonly used design for process heating. It offers the most efficient heat transfer rate and is the most reliable design in practice. The hairpin element design requires removal of the heater bundle to replace individual elements. It is therefore advised where possible to have additional spare elements installed in a heater bundle. This is the most cost-effective design for process heating.

# Withdrawable Element Design

This design allows the operator to change out individual heater elements without the need to remove the heater bundle. This is therefore an excellent solution for applications with hazardous fluids or where it is not practical to drain down a vessel to replace heater elements. However, it should be noted that by design it has a lower heat transfer rate and will have a shorter operating life than the equivalent hairpin design.



# Element Connection to Process Flange

There are two common methods for connection and sealing the electrical heating elements to the process flange:

**Welding**

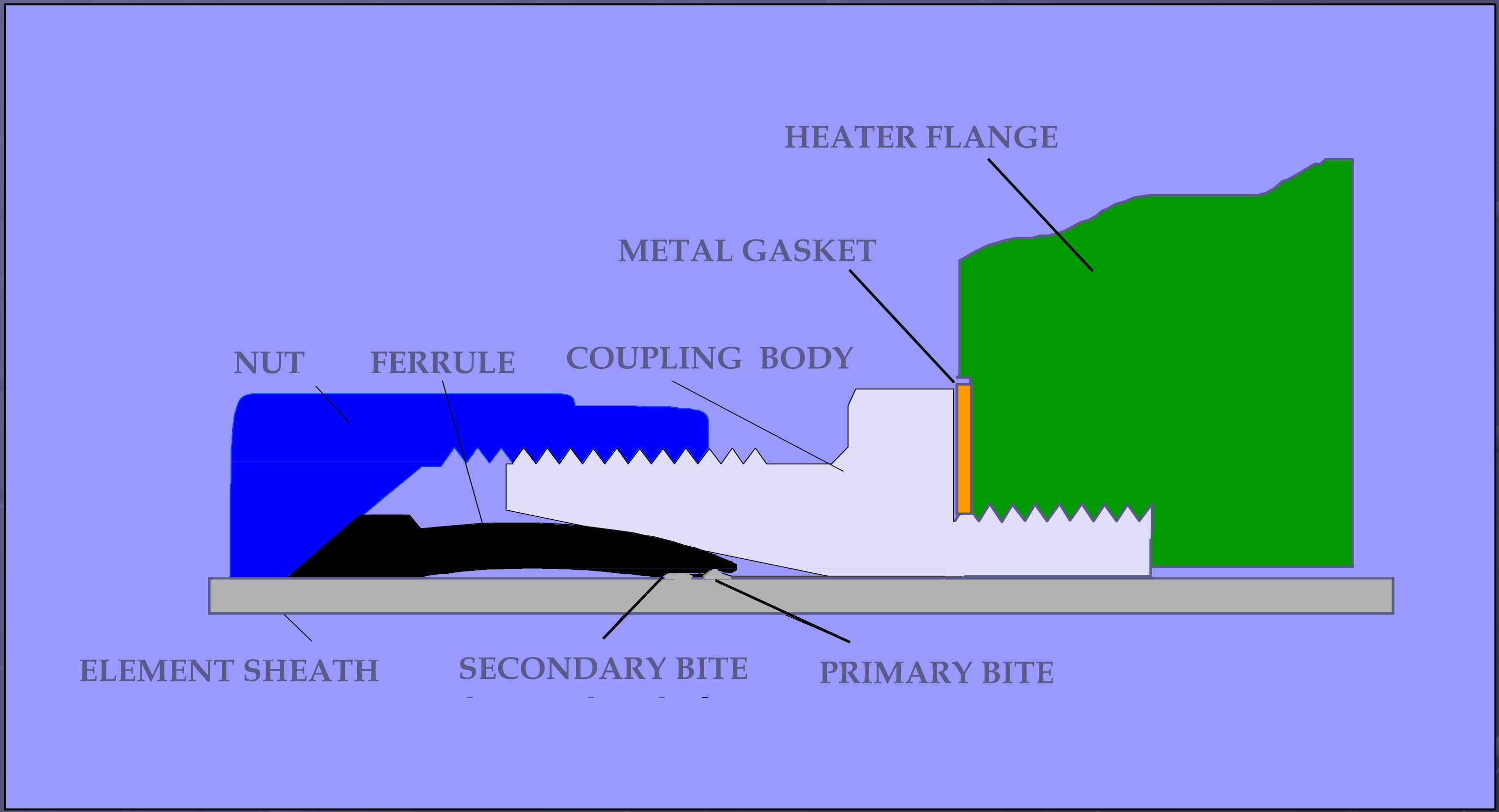
This method provides a positive weld seal to prevent leakage. However, the heater bundle must be returned to the manufacturer should any elements require to be replaced and this method becomes less practical for large heater bundles with hundreds of heating elements.

**Bite Coupling**

This is a very reliable, cost-effective method of providing a gas-tight seal between the electrical heating element and the flange. The couplings allow the operator to change individual elements in the bundle without the need to return the heater bundle to the manufacturer and thus reduces downtime and expense.

# Bite Coupling

Bite couplings are used to provide a 100% tight seal of the element to the heater flange for pressures up to 400 barg. Utilising the 'Bite' coupling allows the removal and replacement of individual elements without the need to replace the complete heater bundle.

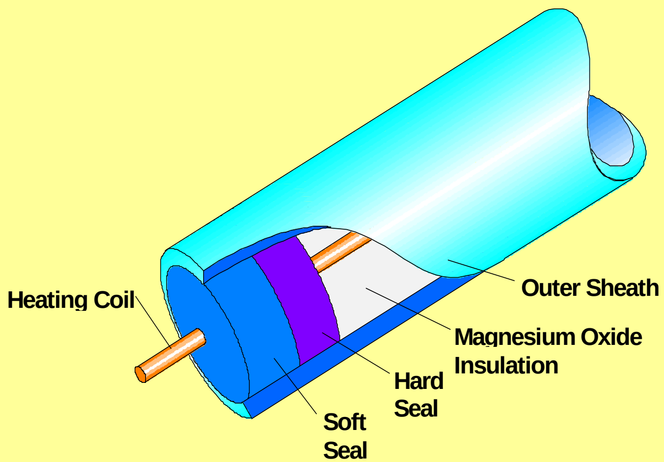



Available in:-

Mild Steel, Stainless Steel, Duplex, 6 Mo, Monel & Titanium

# Element Integrity

Main cause of element/heater failure is moisture ingress/damp elements causing earth fault problems. The amendments 1-5 for EN50 014, EN50 018 & EN 50 019 require specific tests to be carried out to demonstrate adequate element integrity.



Heatex Double Epoxy Seal System

## Tests carried out by BASEEFA

| TEST | MINIMUM | ACTUAL |
|---|---|---|
| Crush test then immersion in water for 30 minutes | 20 MΩ | $1 \times 10^6$ MΩ |
| Climatic chamber 80 °C 90% R,H. for 4 weeks | 20 MΩ | $1 \times 10^6$ MΩ |
| Totally immersed in water for 14 days | 20 MΩ | $1 \times 10^6$ MΩ |
| High temp oven @ 110 °C for 4 weeks then removed and placed in freezer @ - 28 °C for 48 weeks | 20 MΩ | $1 \times 10^6$ MΩ |

NOTE:
The same elements measured 700 MΩ after being left in a weathered outdoor environment for more than two years.

# Process Sizing of Electrical Heaters

The following process information is required as a minimum to be able to correctly size an electrical heater:

- Flowrate ranges (minimum & maximum);
- Inlet & outlet temperatures;
- Specific heat capacity of fluid(s);
- Pressure drop limitations, viscosities.

In addition, it is advisable to design with spare capacity. If the process requires 100 kW then the heater should be capable of providing 10-20% more (ie: 110-120 kW).

# Mechanical Design of Electrical Heaters

The following mechanical information is required as a to be able to correctly size an electrical heater:

- Design codes and regulations (eg: PD5500, PED, ATEX);
- Design temperature & pressure;
- Materials of construction & corrosion allowance;
- Hazardous area classification (eg. Zone 2 Gr. IIB);
- Temperature Class (eg. T3 $\leq$ 200 °C);
- Weatherproof Classification (eg. IP 67).

# Design of Thyristor Control Panel

The following information is required as a to be able to correctly specify a control panel:

- Power supply & it's limitations;
- Contactor or thyristor control requirements;
- I/O, alarm and shutdown requirements;
- Requirements for stages;

# Design Code & Regulation Requirements

The following codes & regulations are applicable to electrical heaters:

- EN50 014 (1977), EN50 018 (EEx'd'), EN50 019 (EEx'e') + Amendments 1-5;
- ATEX 94/9/EC directive;
- Pressure vessel design codes (eg: PD5500);
- PED 97/23/EC directive;
- 73/23/EC low voltage directive;
- 89/336/EEC EMC (electromagnetic) Directive;
- NORSOK & NPD requirements (eg: R-001, M-650);

# Hazardous Area Certification

All hazardous area equipment must be ATEX certified. EEx‘e’ is the preferred standard in Norway and UK.

**All zone 1, IIC, T3, Hazardous Area with two basic types of protection**

**EEx'd'**

**Cast Iron / Aluminium**
**IP66**

**Barrier Glands**
**Cable Size Restriction**
**Fixed Size Box**
**Very Heavy**

**Can Be Subject To Corrosion**

**EEx'e'**

**Stainless Steel 316L**
**IP66/IP67**
**(Hermetically Sealed)**

**Through Glands**
**Removable Gland Plate**
**Single Core Cables**
**Good Cable Clearances**

**No Size Restrictions (2000 x 2000)**
**No Corrosion Problems**

# Control Systems

Electrical heaters are simple devices that provide 100% heat output when current is passed through the elements.

Generally there are two different methods available for modulating heat output:

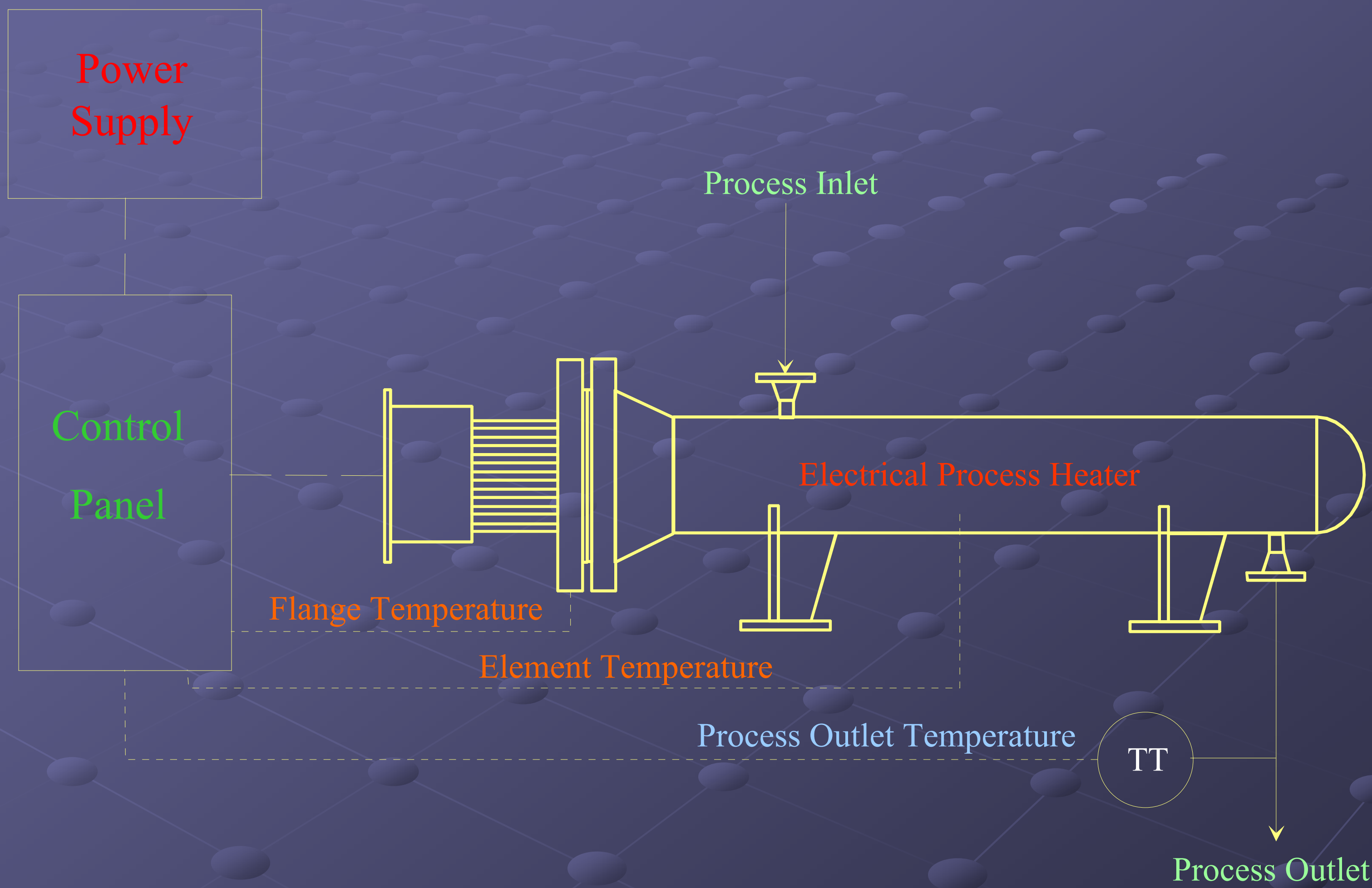
## Contactor Control

A simple contactor device can be used to switch the current on/off to the heater. As the switching method is slow in response to the signal, this method is better suited to fluids with high thermal mass such as water.

## Thyristor Control

A thyristor switches as much as 50 times a second provide a much finer response to heat demand. This allows more precise control of temperature output and is therefore well suited for fluids with a low thermal mass such as fuel gas or fluids that can burn at higher temperatures such as glycol (TEG).

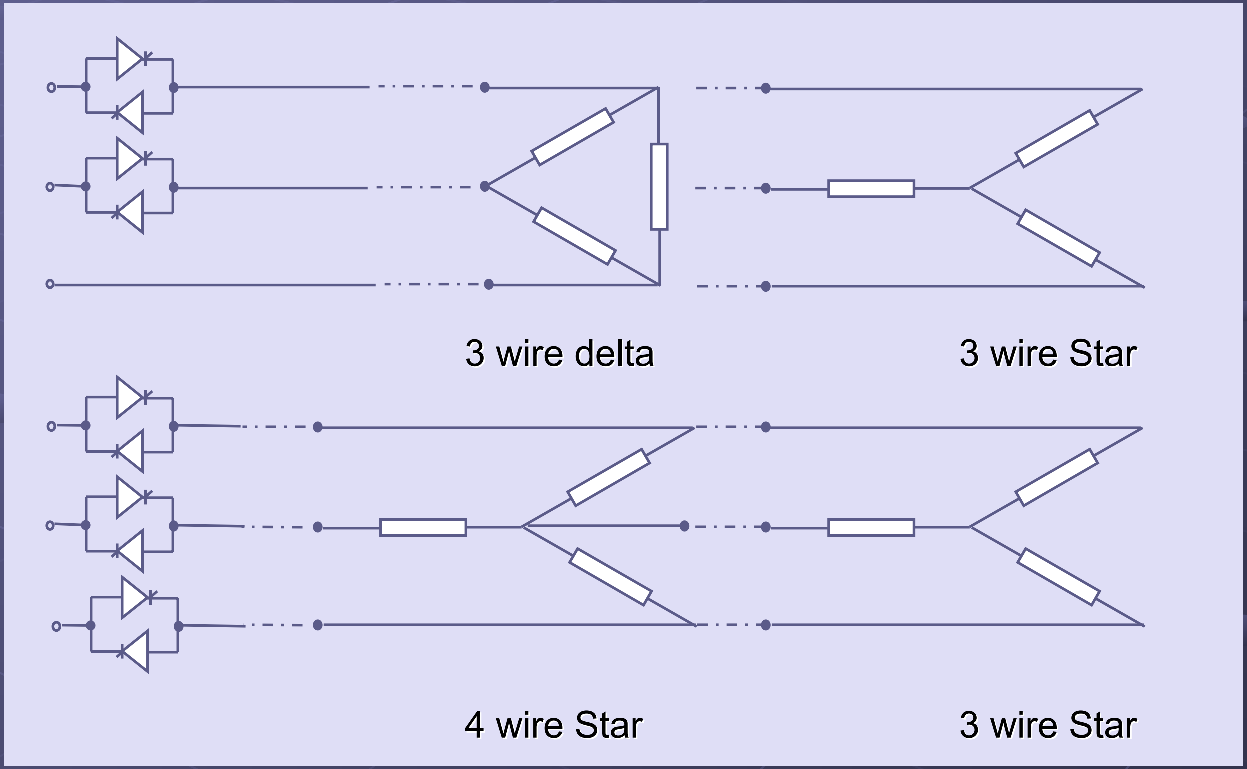
# Typical Control Philosophy



# 3-Phase Control – Delta or Star ?

There are various options for wiring thyristors in a 3-phase circuit. Twin leg “delta” is most efficient and economical for reduced harmonic and heat generation.

*BASIC ELECTRICAL CONNECTIONS*



# Firing Techniques

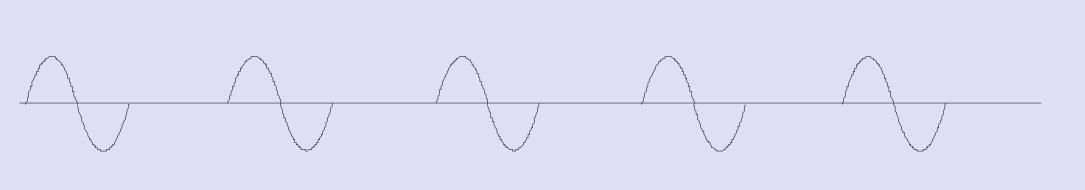
The traditional firing technique used in the first heaters offshore was “phase angle” firing which switched on/off at various angles/parts of the AC sine wave. This provided better load control at the expense of significant harmonic and RFI generation.

The most suitable methods for most applications today are either “burst” or “single cycle” firing techniques which utilise the full sine wave and offer greatly reduced harmonics and RFI.

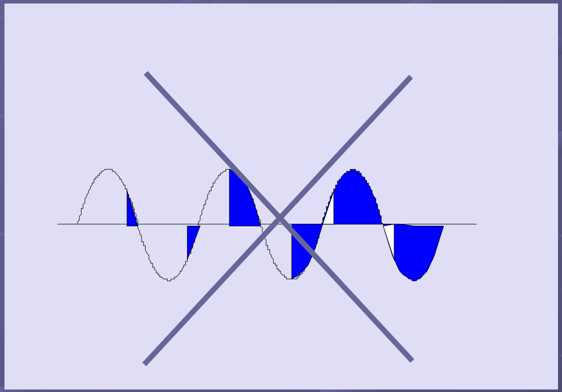
**BURST FIRING**

Recommended for strong power supplies

**SINGLE CYCLE**



Recommended for week power supplies or emergency generators



**PHASE ANGLE**

not recommended due to high harmonics and RFI

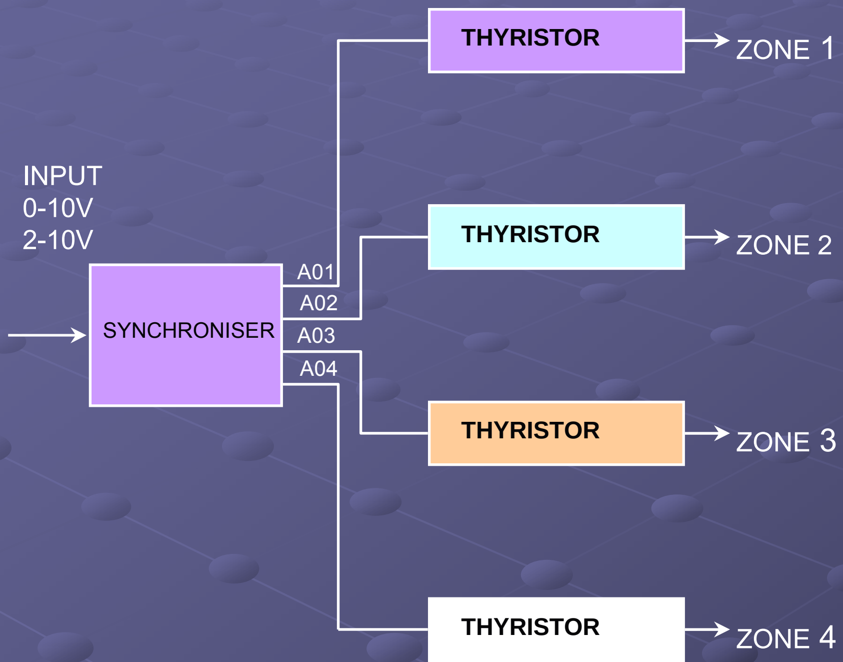
# Load Splitting

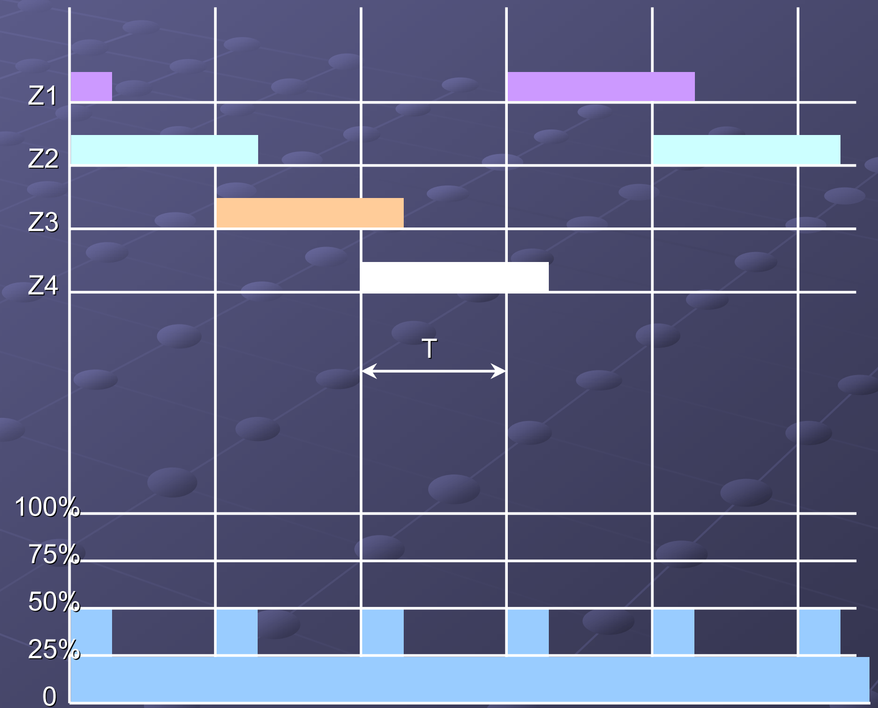
For large loads, single stage thyristor switching will cause supply problems i.e. generator hunting & lights flickering, regardless of whether Single Cycle or Burst Firing techniques are used.

In this case some form of "Load Splitting" technique should be considered.

| | |
|---|---|
| Thyristors throughout | (gas heating applications with varying flow rates) |
| Thyristor / Contactor | (liquid heating or constant gas flow rates) |

# All Thyristor *All zones modulating*



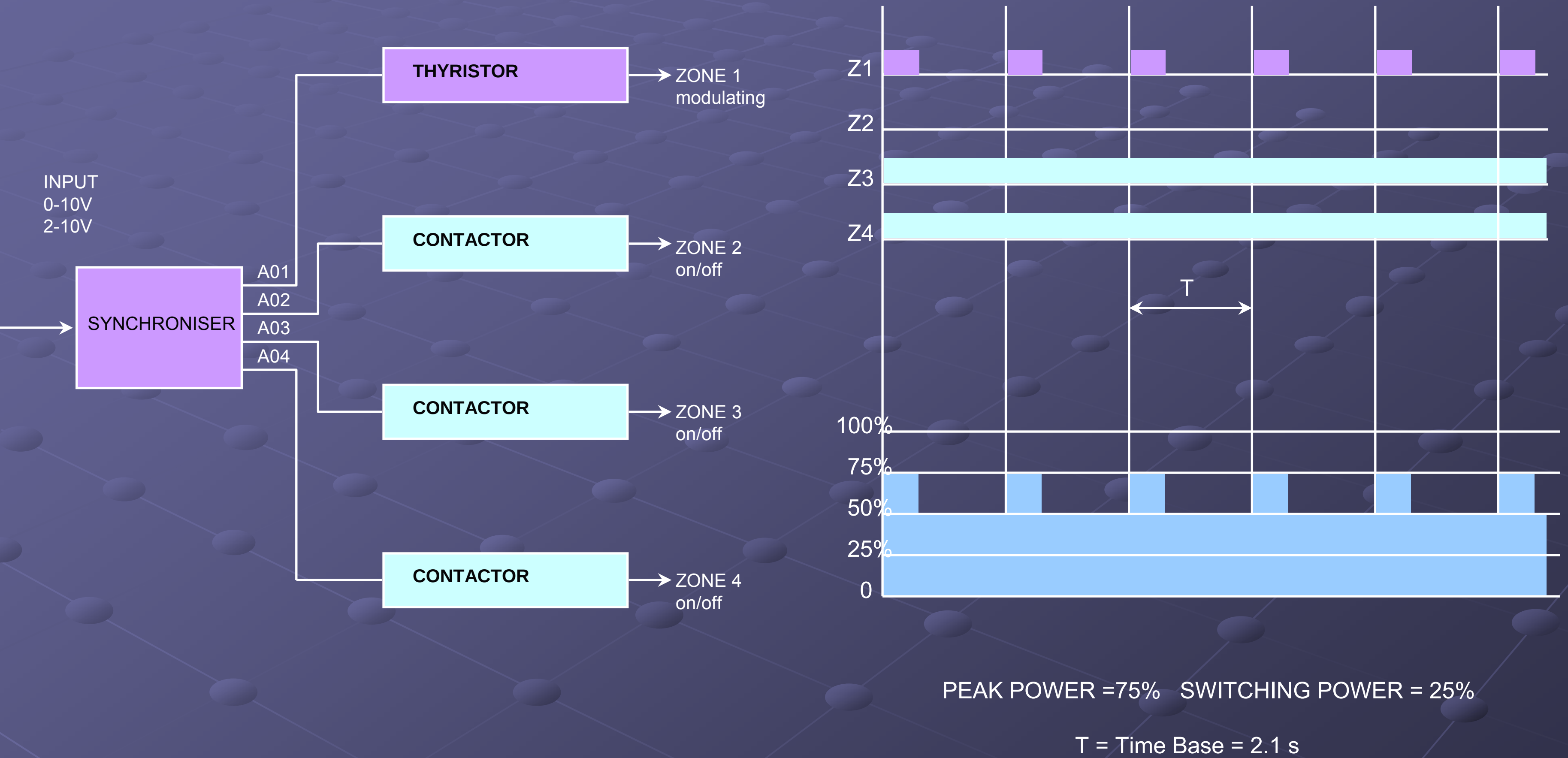




PEAK POWER = 50%  SWITCHING POWER = 25%

T = Time Base = 2.1 s

*Ideal for all kind of heating medium including* ***low flow*** *service*

# Thyristor/Contactor *First zone modulating*




*Ideal for liquid heating or constant flow gas heating*