The Usability of Convection in CAB Technology

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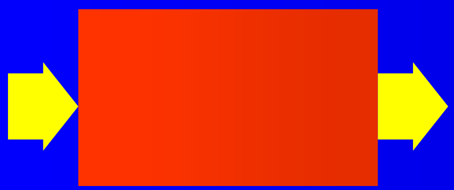
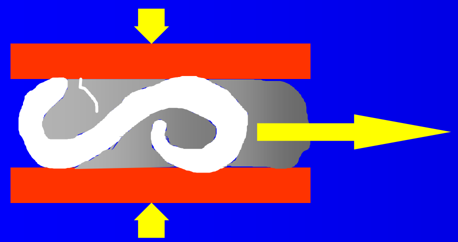
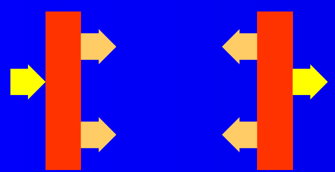
Fundamental Modes of Heat Transfer



Conduction is the transfer of heat within a body from a high temperature region to a lower temperature region.



Convection is the transfer and exchange of heat, due to the mixing motion and movement of a fluid.



Radiation is energy transfer through a transparent medium or empty space.

The Basic Equations

Conduction

$$q = k\frac{A}{L}\Delta t$$

q = rate of heat flow
A = cross sectional area
L = length
k = thermal conductivity
Δt = temperature difference of the two surfaces

Convection

$$q = h\,A\,\Delta t$$

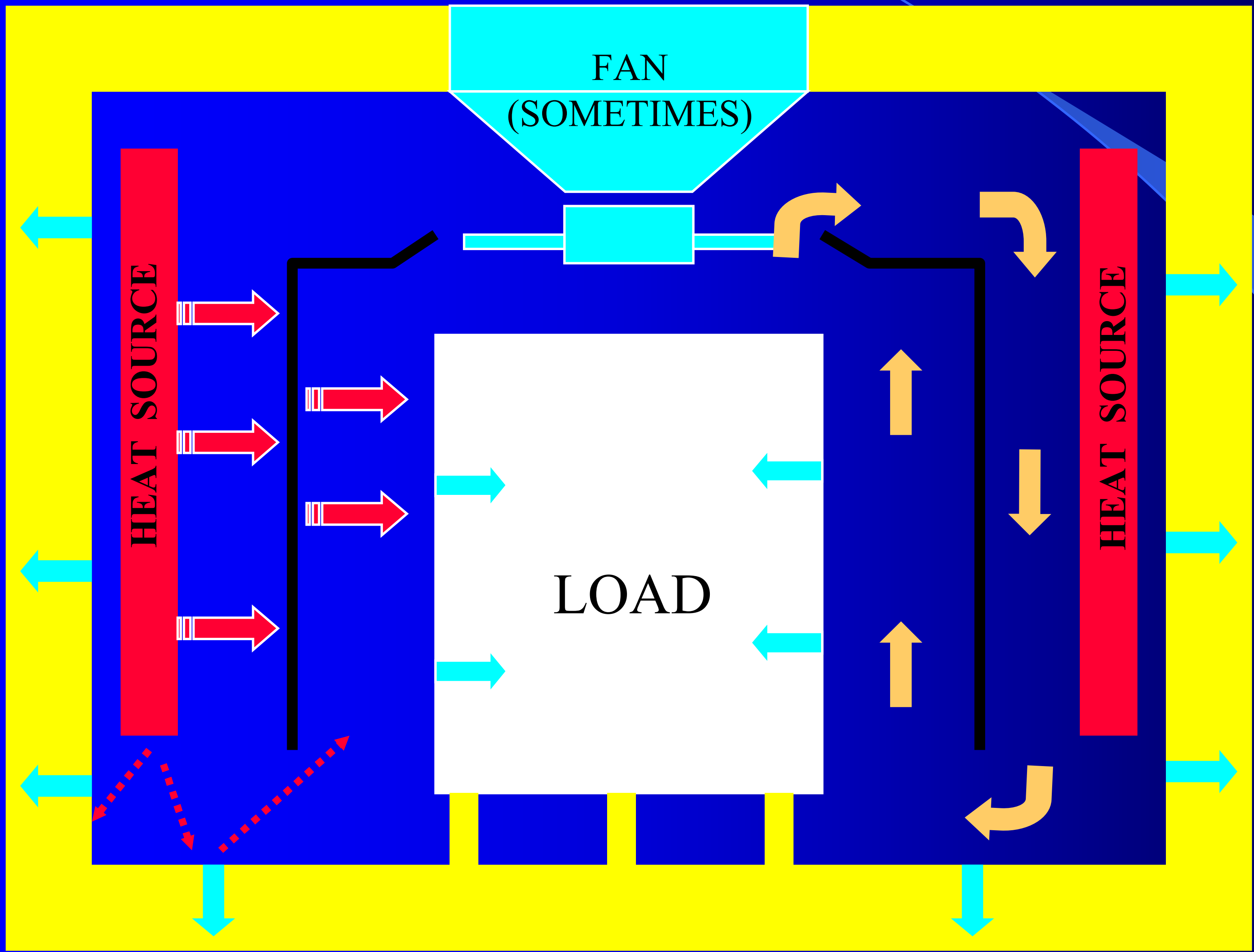
q = rate of heat flow
A = surface area
h = surface coefficient
Δt = temperature difference between the surface and the fluid.

Radiation

$$q = \sigma\,A\,T_R^4$$

q = rate of heat flow
A = exposed area
σ = a natural constant (Stefan Boltzmann)
T_R = absolute temperature

Basic Process Furnace & The Basic Thermal Mechanisms

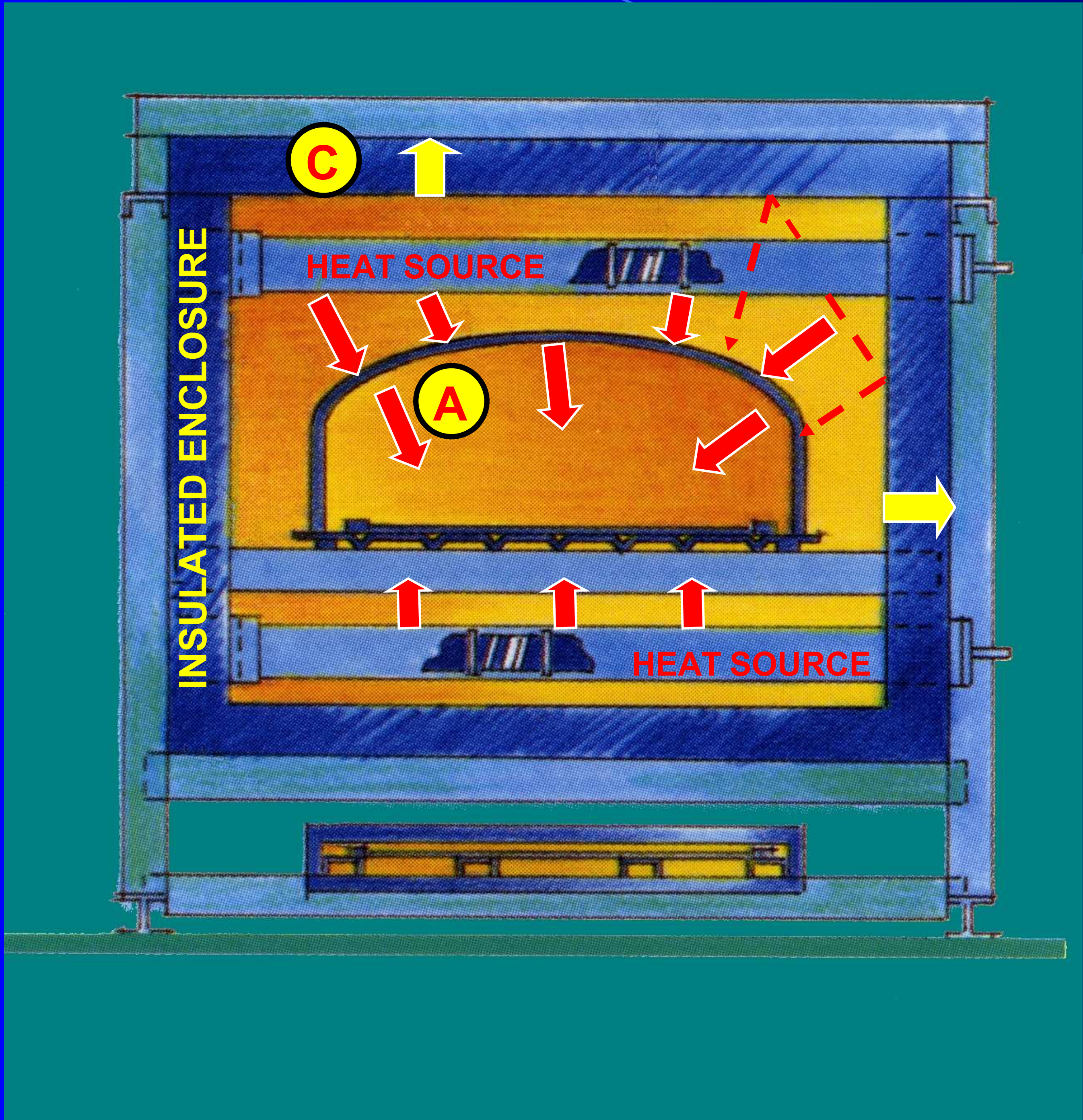


Radiation

Convection

Conduction

Radiation Brazing Chamber

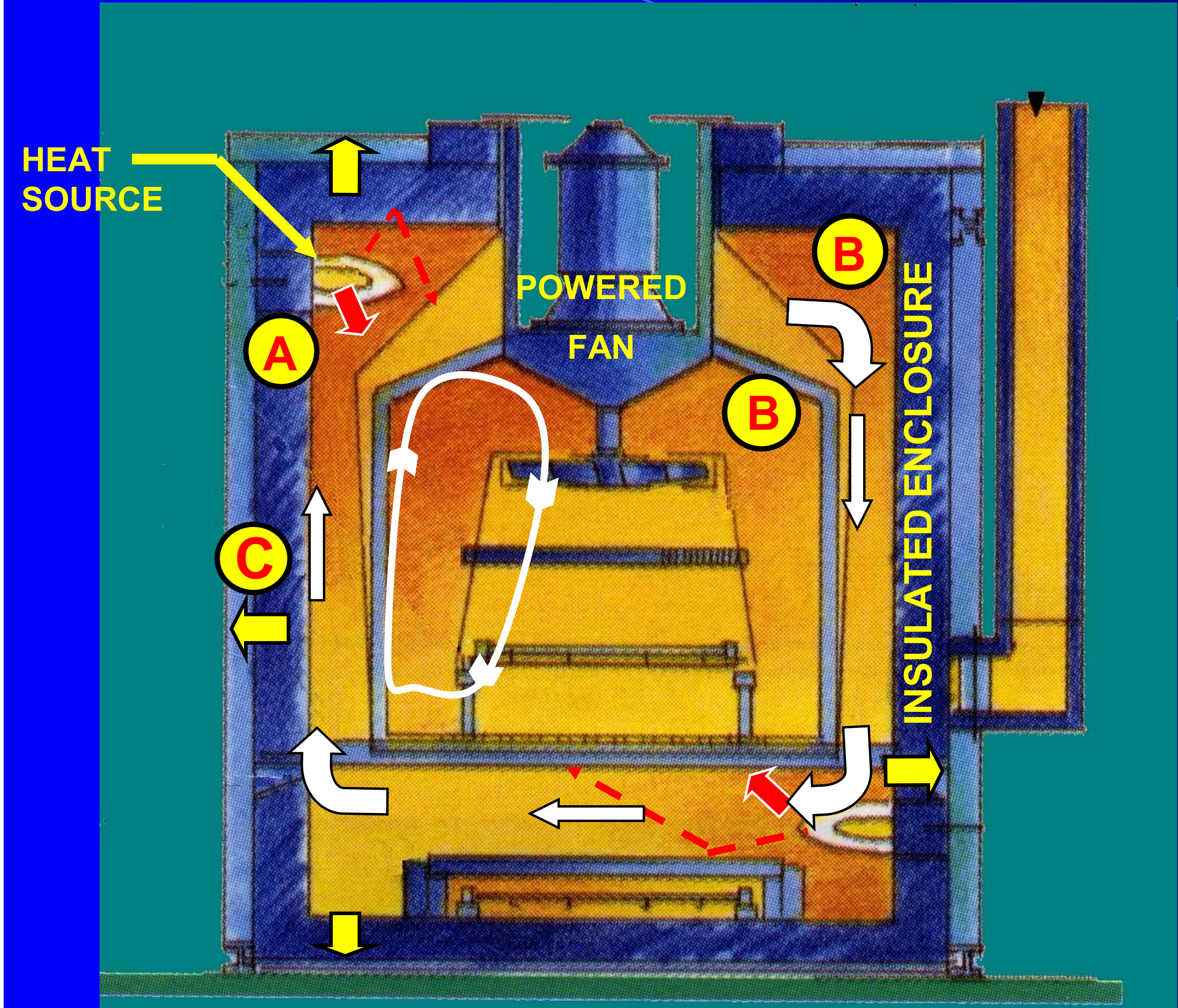


A = Radiation

B = Convection

C = Conduction

Convection Brazing Chamber



A = Radiation

B = Convection

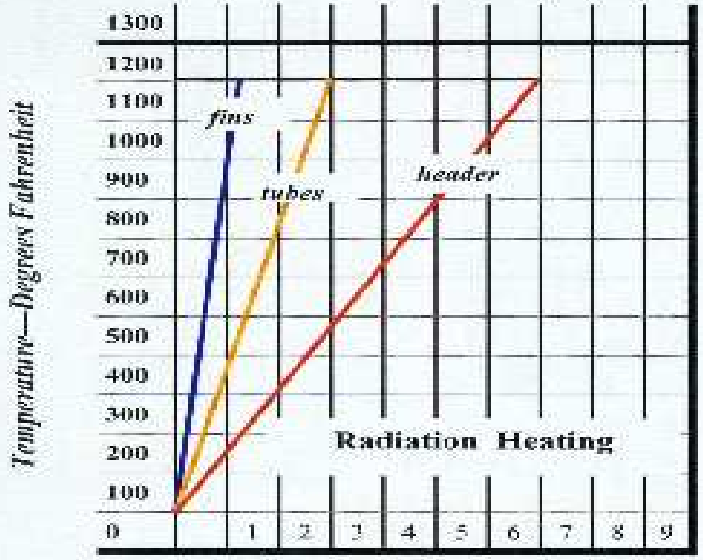
C = Conduction

SECO/WARWICK

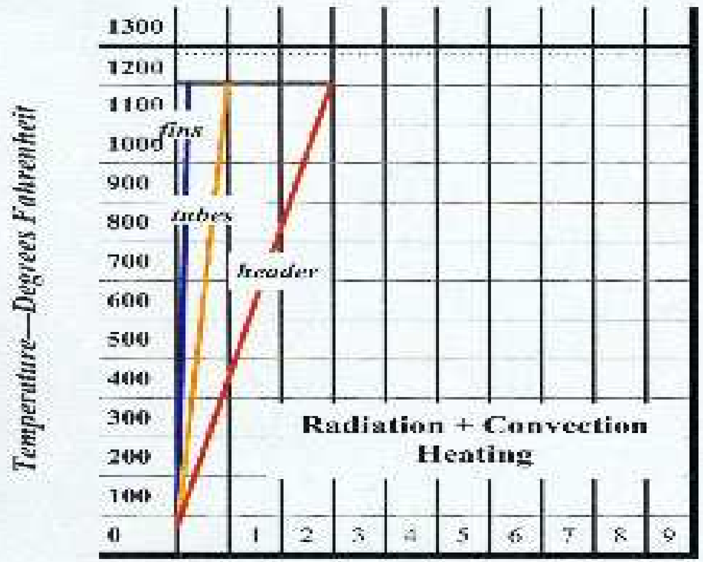
Compare Heat Transfer by Radiation and Radiation + Forced Convection for Copper/Brass Radiator and Aluminum Radiator

Copper/Brass					Aluminum				
Radiator Dimension = 864 mm x 325 mm x 32mm (34" x 12.8" x 1.26")					Radiator Dimension = 864 mm x 325 mm x 32mm (34" x 12.8" x 1.26")				
Component	Material	Thickness in inches	Weight in pounds	Heat Transfer Surface Area in square feet	Component	Material	Thickness in inches	Weight in pounds	Heat Transfer Surface Area in square feet
Fins	Copper	.002	4	87	Fins	Aluminum	.006	3.7	87
Tubes	Brass	.005	6.2	21.2	Tubes	Aluminum	.015	4.5	21.2
Headers	Brass	.039	2	1.9	Headers	Aluminum	.117	3.15	1.9

Copper/Brass

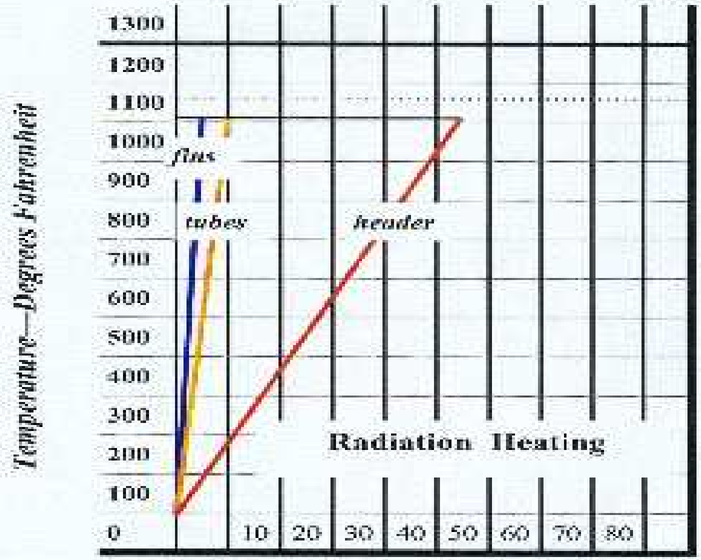


Time—Minutes
Heat to 1208° F (653°C) in 1280 °F (693° C) Furnace

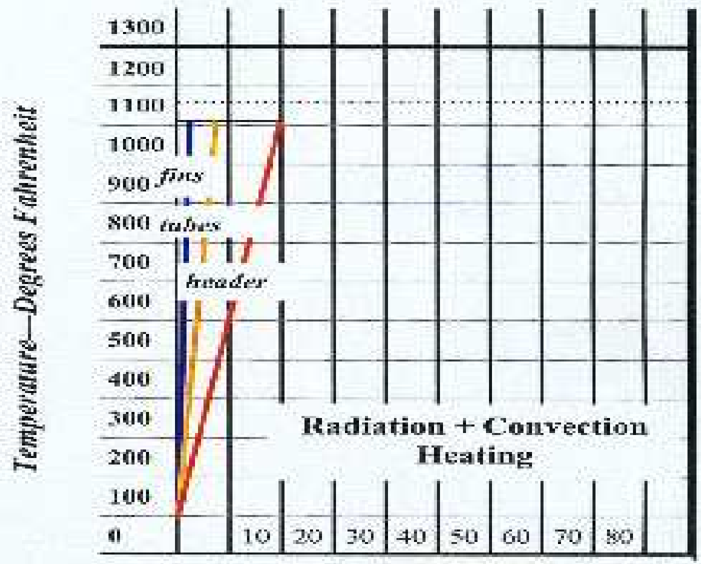


Time—Minutes
Heat to 1208° F (653°C) in 1280 °F (693° C) Furnace

Aluminum



Time—Minutes
Heat to 1130° F (610°C) in 1280 °F (621° C) Furnace

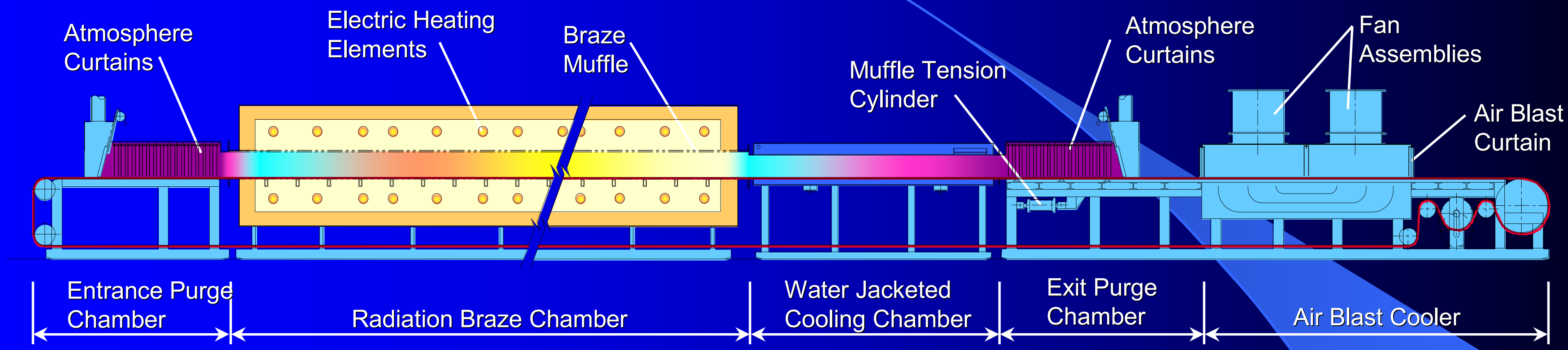


Time—Minutes
Heat to 1130° F (610°C) in 1280 °F (621° C) Furnace

CAB Furnace Systems

- Radiation
- Convection Preheat / Radiation Braze
- Convection
- Semi-continuous
- Batch

RADIATION CAB Furnace

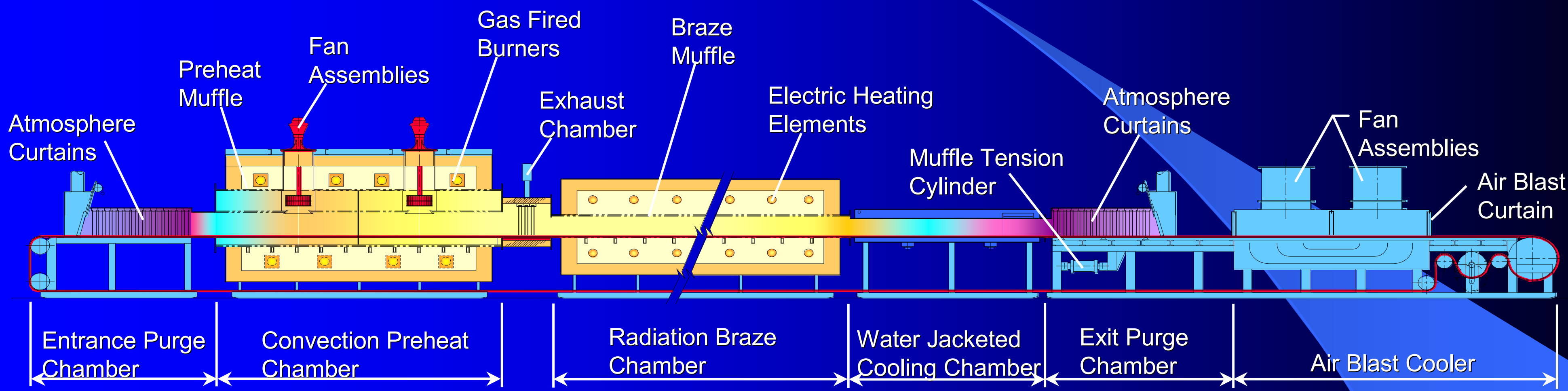


Benefits of RADIATION Type CAB Furnaces

- Ideal method for brazing similar size products in a continuous flow environment.
- Poor flexibility.
- Low atmosphere consumption.
- Low required maintenance.
- Low investment cost.

CONVECTION PREHEAT

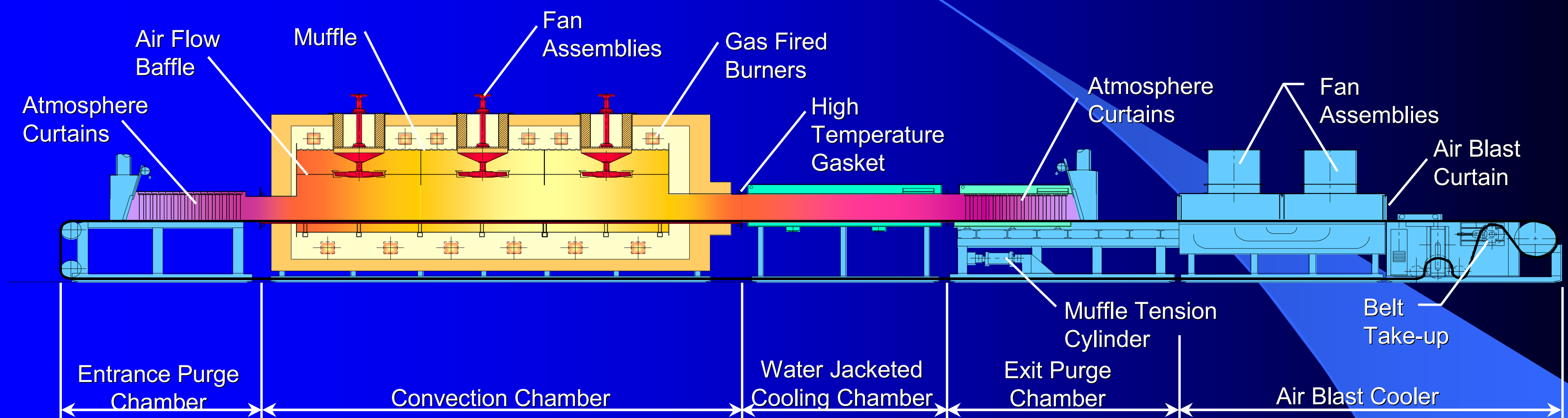
Radiation Braze CAB Furnace



Benefits of CONVECTION PREHEAT RADIATION BRAZE CAB Furnaces

- Ability to run products of different mass and dimension in the same cycle.
- Applicable when your brazing needs are more diverse.
- More forgiving when running products intermittently.
- Convection preheating decreases product cycle time.
- Physical length of furnace is reduced.
- Low atmosphere consumption.
- Medium investment cost.

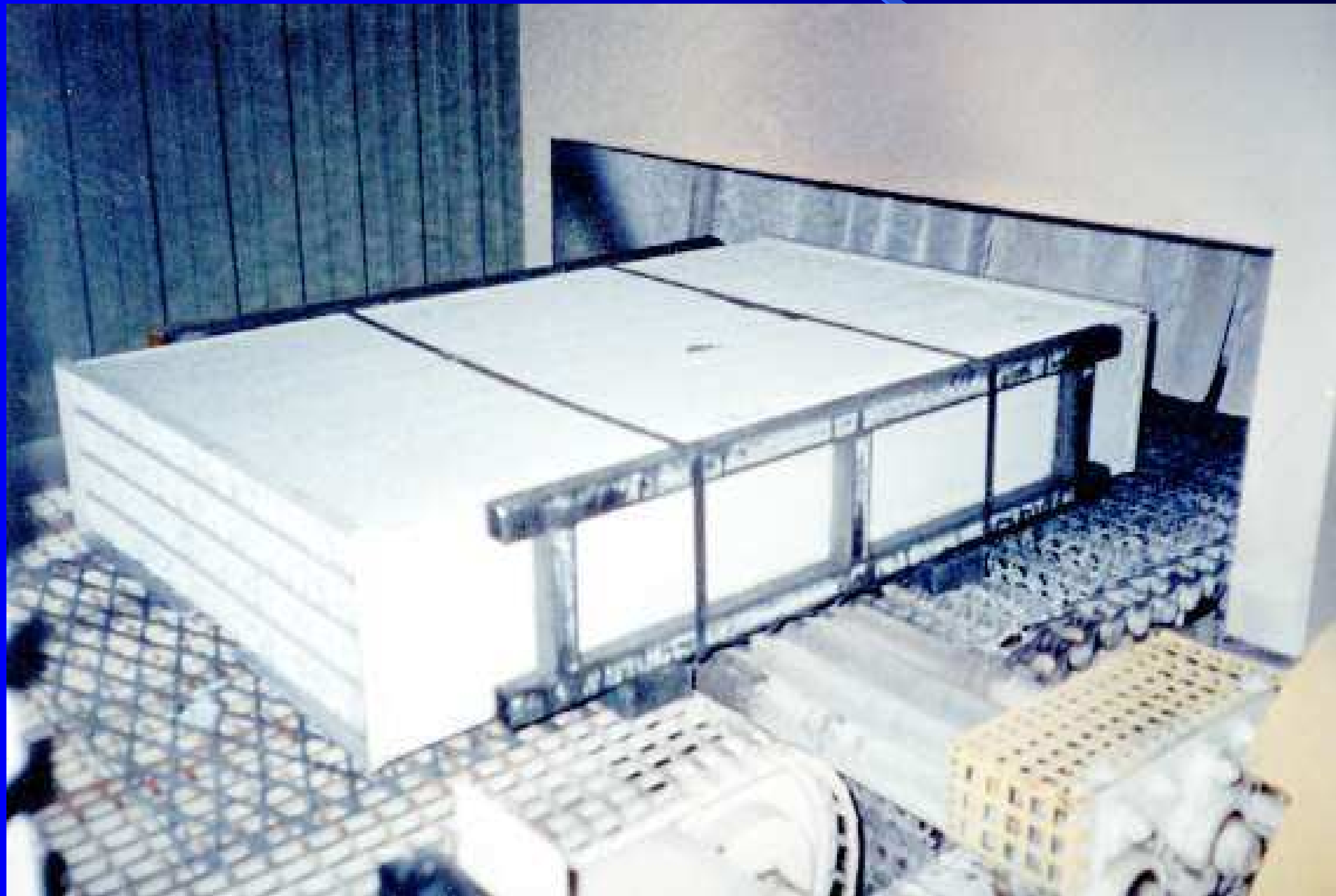
CONVECTION CAB Furnace



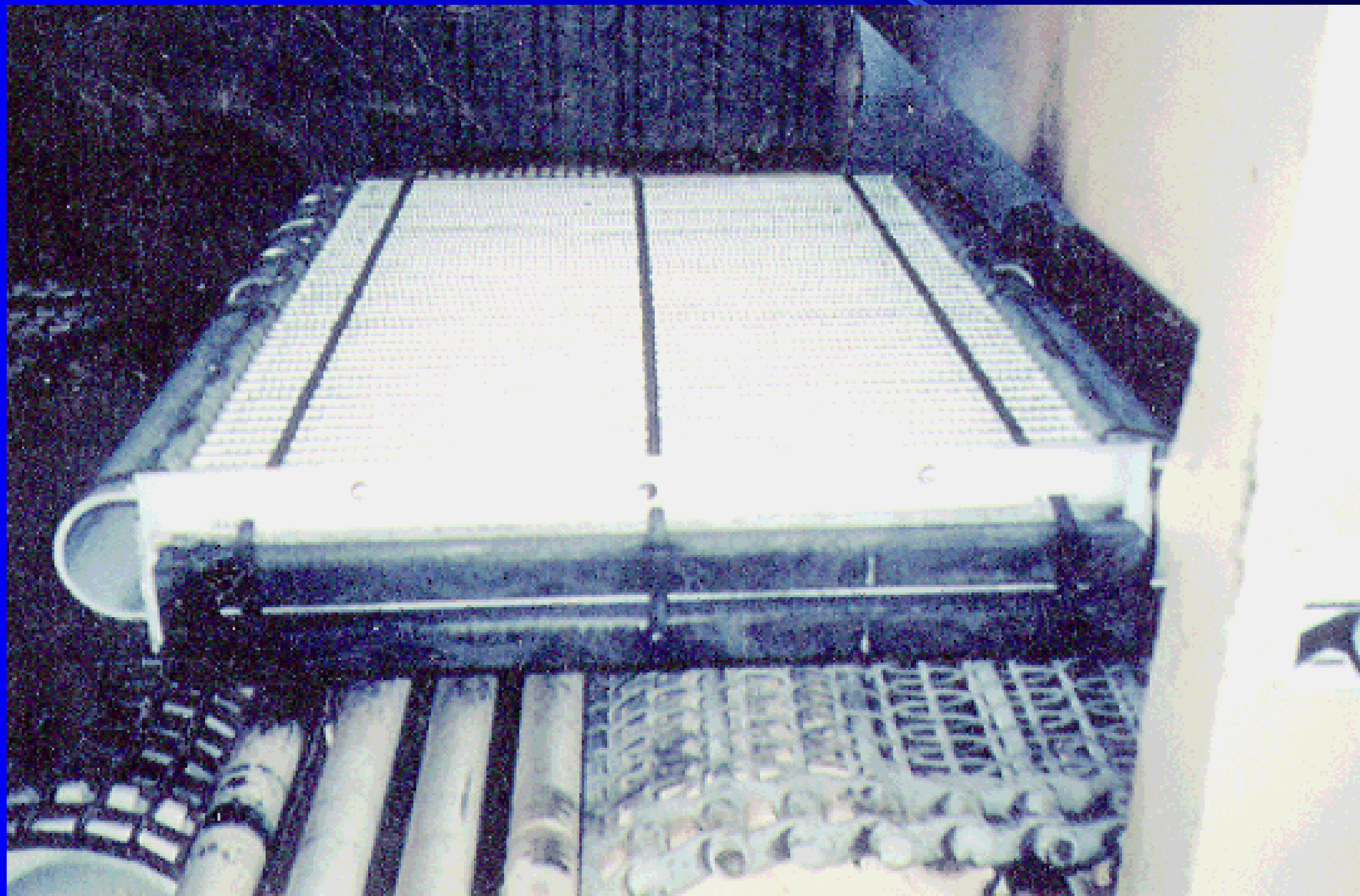
Benefits of CONVECTION Type CAB Furnaces

- Most efficient means to braze a wide variety of products in the shortest cycle time.
- Increased product throughput.
- Excellent product temperature uniformity by means of convection heating.
- High brazing efficiency and furnace flexibility.
- Requires less floor space with higher production rates.
- Medium atmosphere consumption.
- Higher investment cost.

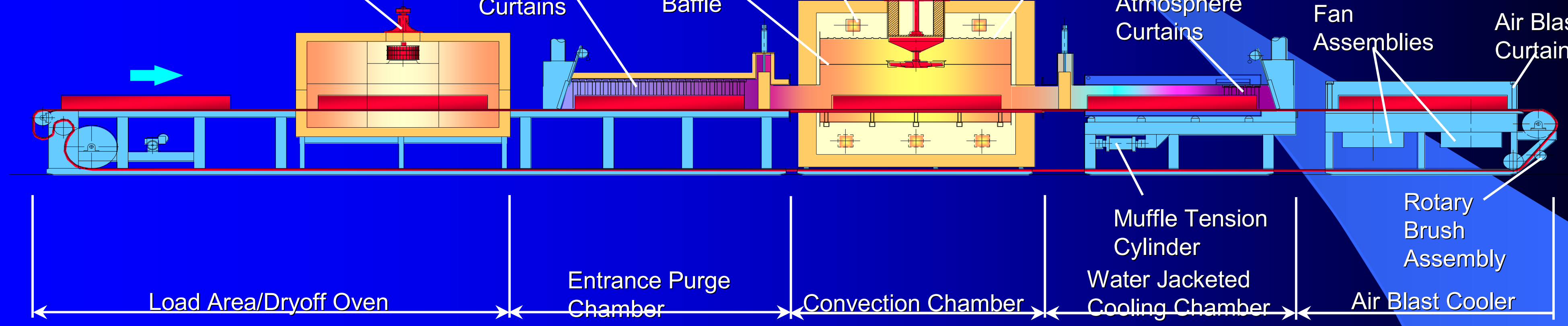
Convection Furnace
Example of brazed core



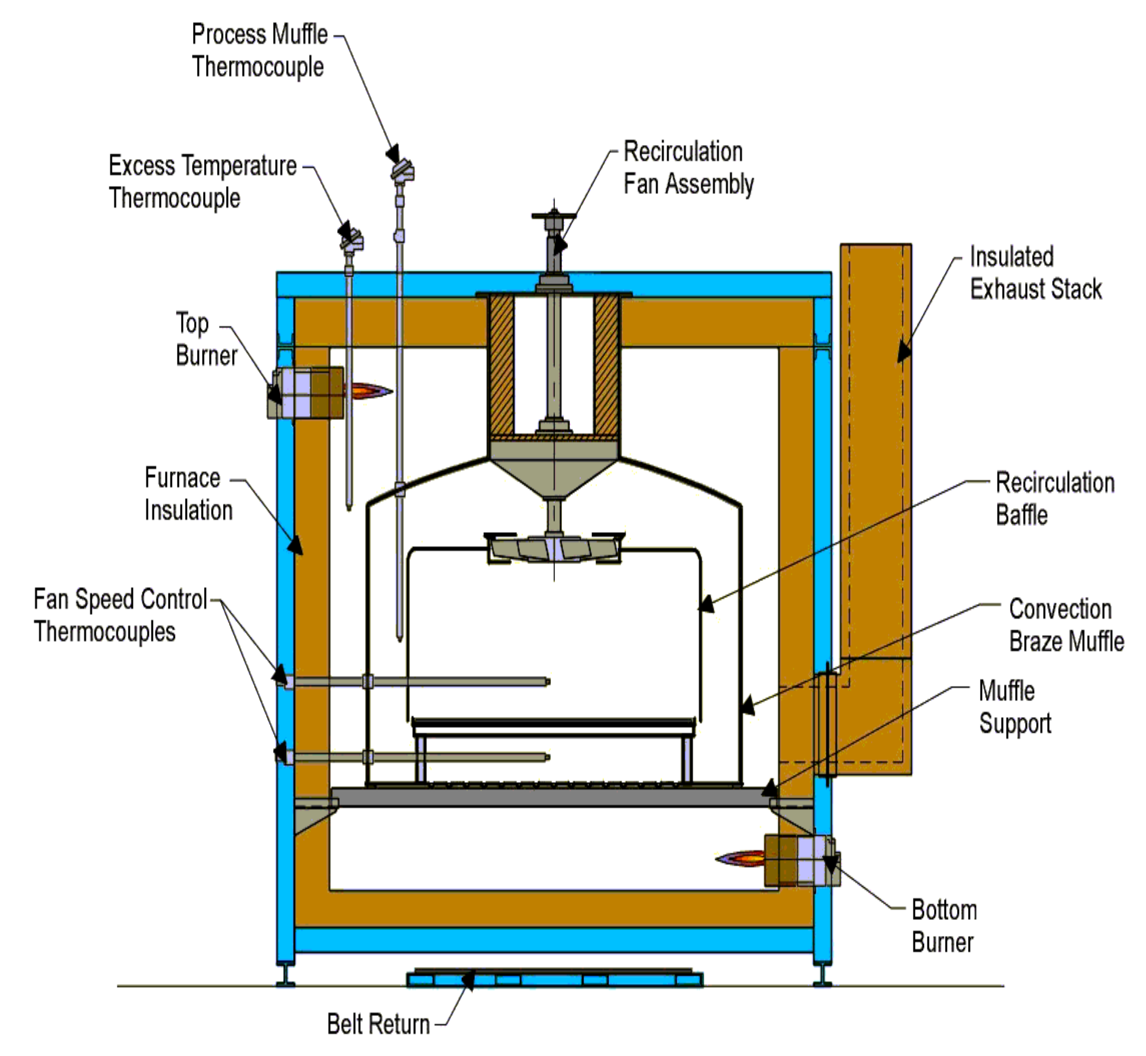
Convection Furnace
Example of brazed core



Semi-Continuous CONVECTION CAB Furnace (based on SECO/WARWICK ACTIVE Only®)



Semi-continuous CAB Furnace Active Only®



Control STRATEGY:

- Fan Speed Control T/Cs read load temperature and control the fan speed to obtain as fast as possible heating rate during heating phase and the best temperature uniformity at brazing phase.
- When fan speed T/Cs read the set value, soak time is started to be counted.
- Slowing down of fan speed at brazing temperature (when the clad is molten) prevents mat looking parts.

Results of control strategy:

- Shortest possible heating time for every load.
- Fixed soak time.

PC/PLC Furnace Control System ACCUBRAZE®

RECIPE

Semi-continuous CAB Furnace Active Only®

TYPICAL BRAZING TIMES FOR AUTOMOTIVE HEAT EXCHANGERS IN RADIATION FURNACE:

Radiators:	12 - 16 min
CAC	15 - 24 min
Condensers	12 - 16 min
Heater cores	10 - 14 min

Practical benefit of Active Only® semi-continuous furnace:

- load of radiators followed by load of CAC, followed by double layered condensers followed by load of heater cores, each load of different mass

Same high brazing quality for variety load obtained using the same parameter settings.

Active Only®
Semi-continuous Furnace System

Flexibility

Active Only®
Semi-continuous Furnace System

Flexibility

Double layered condensers

Semi-continuous CAB Furnace Active Only®

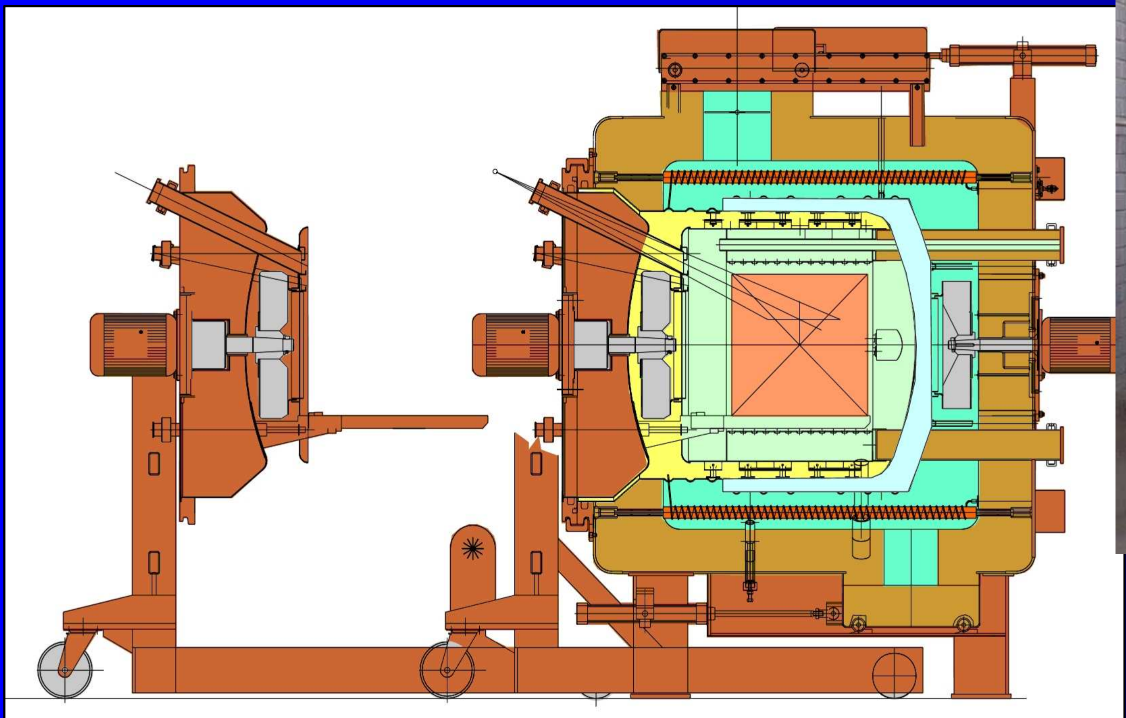
- Core Size 2,000 mm x 1,300 mm x 100 mm Thick.
- Considered to be one of the largest cores brazed using a non corrosive flux.

Semi-Continuous CONVECTION CAB Furnace (based on SECO/WARWICK ACTIVE Only®)

- Ability to operate on a "part-time" basis.
- Lower production rates but with a very high product mix.
- Minimal heat up time from ambient temperature.
- Flexibility when running different size loads one after another.
- Excellent temperature uniformity.
- Ideal for the aftermarket product lines.

BATCH type
Convection CAB Furnace

BATCH Furnace = Prototyping, R&D work or lower production purposes



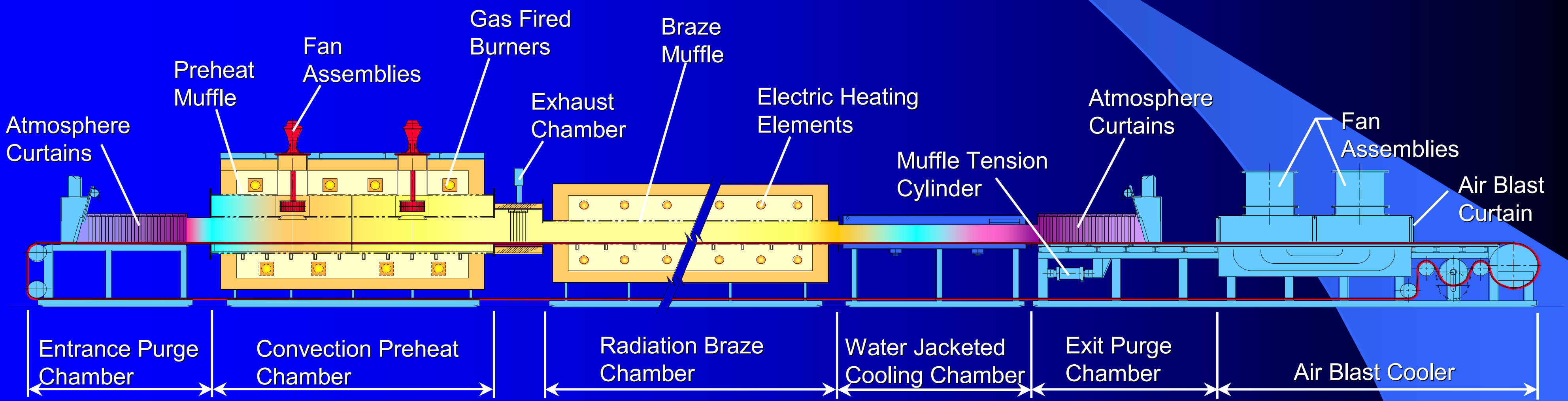
CONVECTION PREHEAT CHAMBER to the Radiation CAB Furnace

- MORE THAN DOUBLES production capacity by around 250 k EUR investment.

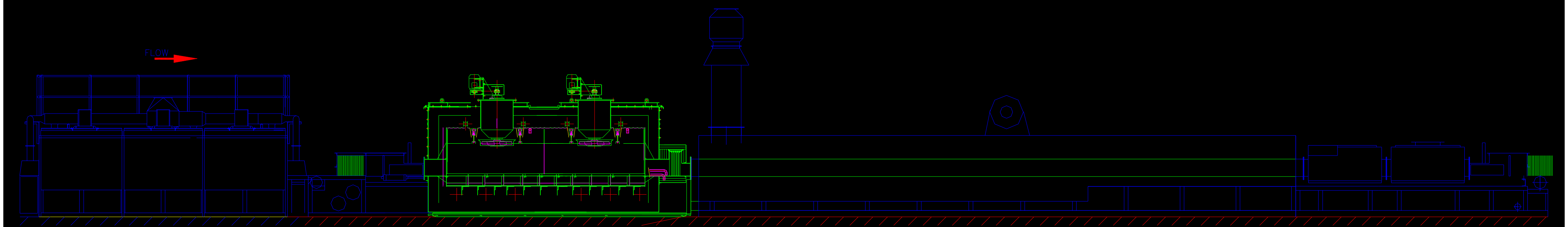
  Example: condensers brazing from 120 pcs/h (on one layer) to 300 pcs/h (two layers).
- Enables brazing in one shot compact „sandwich" load (connected radiator and condenser).
- Higher flexibility of the furnace enables to braze wider product range on the same brazing parametres.
- Parts are heated up to the temperature of 450 – 520 C in the convection chamber before entering radiation chamber.

CONVECTION PREHEAT CHAMBER to the Radiation CAB Furnace

- New equipment

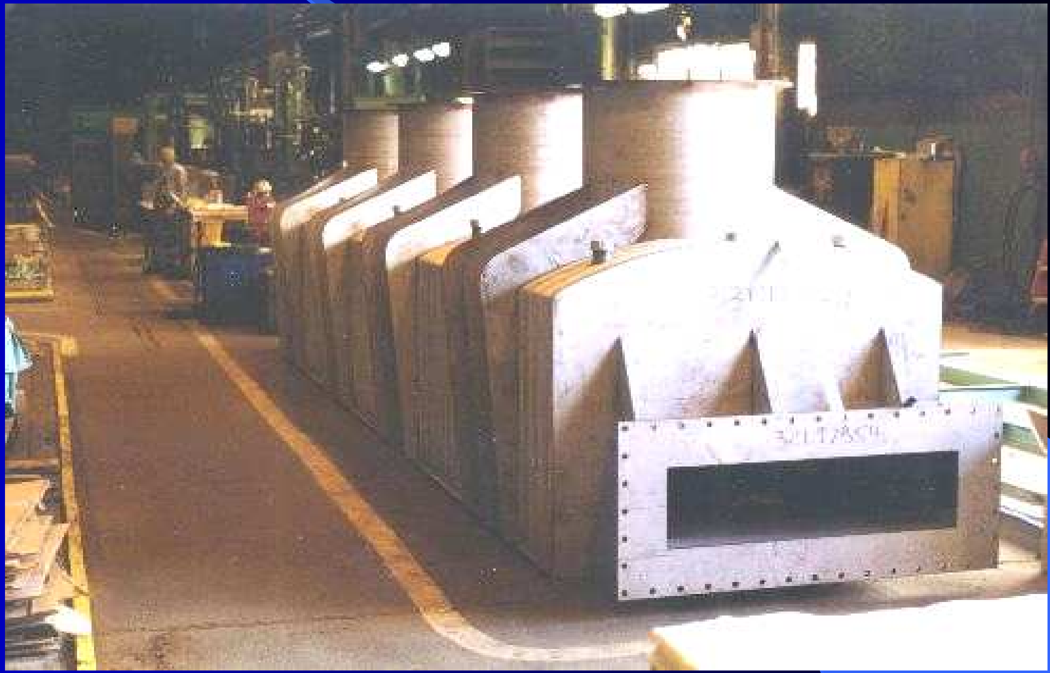


- Refurbishement



Convection Muffle Design

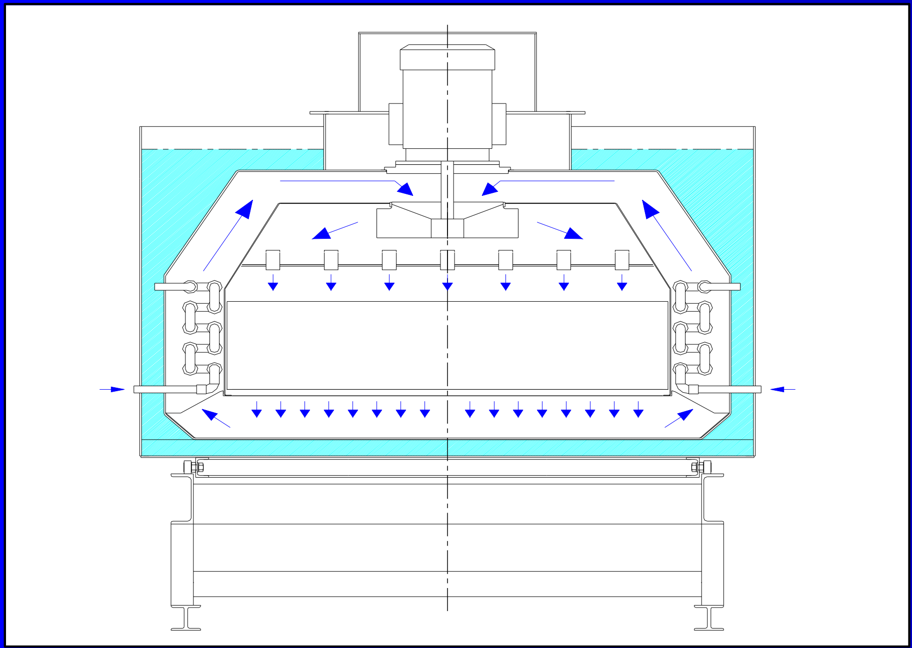
- Patented, D-shaped, corrugated design for longer life.
- 6mm 316L Stainless Steel design.
- Internal recirculation baffles for proper heat distribution and uniform atmosphere circulation.
- Bottom plates maximize muffle life.



Convection Fan Design

- 5.5 kW fan assembly designed for robustness and water cooled.
- Fan bearings are located close to fan blade to prevent vibration.
- Coated fan blades to resist corrosion and reduce flux build-up to keep fan in balance.

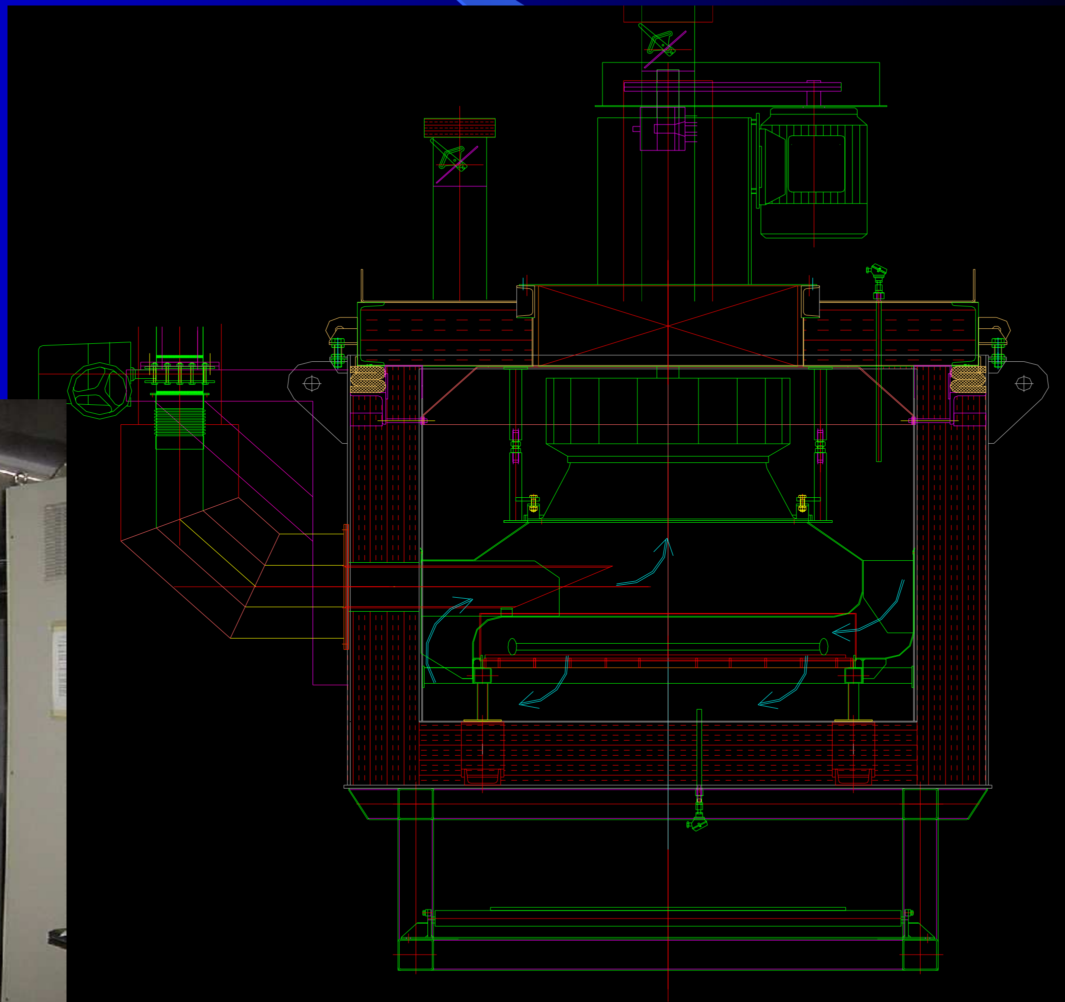
Water Jacketed Cooling Chamber With Fast Fan Controlled Cooling



- Accelerate the cooling cycle by adding a fan and heat exchanger to the water jacketed chamber.
- Cool the core by means of convection cooling while still under the nitrogen atmosphere in the water jacket.
- Air distribution nozzles are used to achieve a uniform cooling load area.
- Combination of a typical water jacketed cooling chamber with a fan and cooling coils can achieve a cooling rate of 3 – 6 °C per second down to 250 °C.

Degreaser – special air circulation

- Improves degreasing efficiency inside the tubes
- Reduces total degreasing time to 2,5 minutes.



Time to braze in various furnace configuration

	Radiation [min]	Convection preheat/ radiation braze [min]	Convection [min]
Radiators	12 ÷ 16	3 + 7 ÷ 4 + 8	6 ÷ 8
Condensers	12 ÷ 16	3 + 7 ÷ 4 + 8	6 ÷ 8
Evaporators	14 ÷ 20	3 + 7 ÷ 5 + 9	6 ÷ 8
CAC	15 ÷ 24	4 + 8 ÷ 6 + 9	6 ÷ 8
Heater cores	10 ÷ 14	3 + 7 ÷ 4 + 8	6 ÷ 8

Semi-continuous Active Only ®:
Time controlled automatically by the system,
individually for each load
basing on real load temperature increase

Advantages of using convection:

- Higher heating rates
- Higher temperature uniformity, usually better than +/-3° C
- The same heating time for fins and headers enables using for the whole core the same material: clads AA 4343 or AA 4045 instead of AA 4045 for fins and AA 4049 for header

Summary:

Furnace type	Radiation braze	Convection preheat/ radiation braze	Convection braze
Time to braze	High	Medium	Low
Product intermixing	Low	Medium	High
Temperature uniformity	Medium	Medium/High	High
Atmosphere consumption	Low	Low	Medium
Required maintenance	Low	Low	Medium
Brazing efficiency	Medium	Medium/High	High
Flexibility	Low	Medium	High
Cost	Low	Medium	High

Summary:

- A wide range of CAB furnaces utilising convection is available.
- Convection increases flexibility, and should be considered in the case of diversed brazing needs.
- Special convection CAB furnace design features are developed.
- An addition of convection preheat chamber for the radiation furnace can double CAB line productivity with investment cost of 30% of the new line.

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THANK YOU FOR ATTENTION