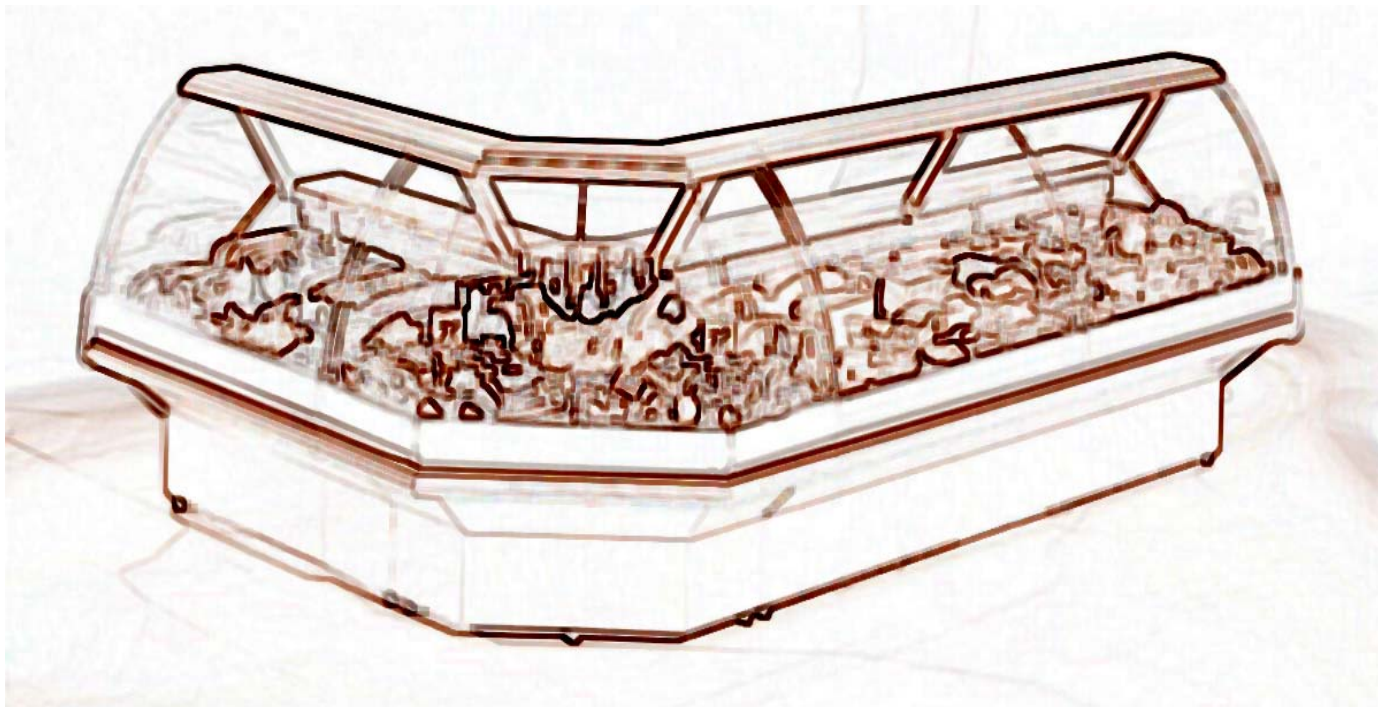
CAREL

E²V training course

- Algorithm fundamentals - Parameters and setup

- E²V training course -

Basic setup, unit startup and superheat regulation for low-end refrigeration



Fondamental parameters

Driver parameter	Example values
• VALVE TYPE	Carel E²V - Sporlan SEI - Alco EX7
• REFRIGERANT TYPE	R22 - R134a - R410a - R744
• STAND ALONE/pLAN?	Y/N (on-off menagement)
• PRESSURE PROBE RANGE	-0.5/7barg or 0/10barg or 0/30barg

• VALVE START POSITION	Usually from 30% to 80%
• SUPERHEAT SETPOINT	Usually from 4°C to 8°C

Fondamental parameters: VALVE TYPE

VALVE TYPE

- Different driving CURRENT (mA)
- Different STEP NUMBER
- Different DUTY CYCLE

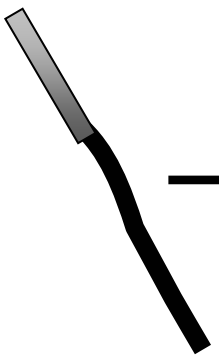
<u>WRONG valve type means</u>:

- Stepper motor ERROR (*<u>it could be damaged by excessive current!)</u>*
- The valve does NOT MOVE
- The valve moves in the WRONG DIRECTION
- The unit stops for HP or LP after few seconds from start

Fondamental parameters: REFRIGERANT

REFRIGERANT TYPE

Evaporating pressure → **Evaporating temperature**



Suction temperature

→ **SUPERHEAT!**

<u>WRONG refrigerant type means</u>:

- WRONG SUPERHEAT and WRONG evaporating temperature

Refrigerants	
R22	R507
R134a	R508A
R404a	R290 (propane)
R410a	R600 (butane)
R407C	R717 (ammonia)
	R744 (co_2)

Fondamental parameters: STAND ALONE

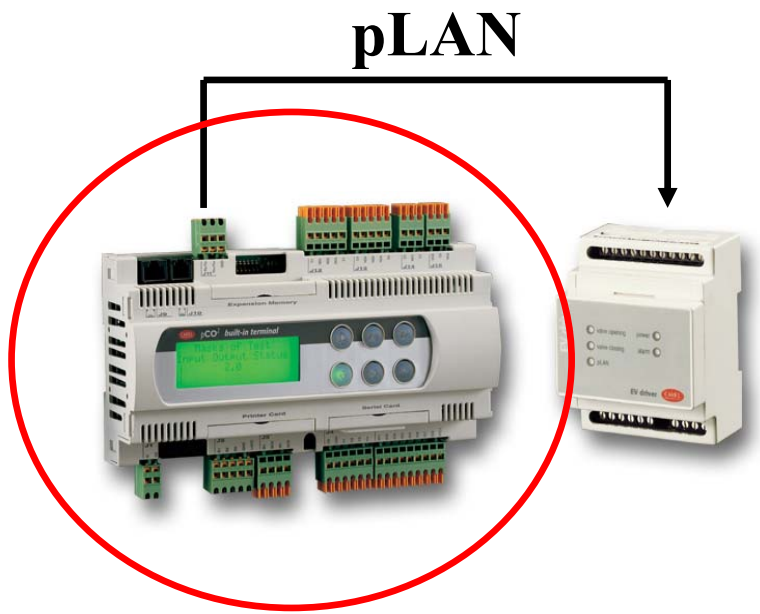
STAND ALONE MODE

1-NO! You enable the pLAN on-off control

2-YES! You enable the DIGITAL INPUT on-off control

WRONG stand alone setting:

- The VALVE does NOT START with the unit



Fondamental parameters: PRESSURE PROBE RANGE

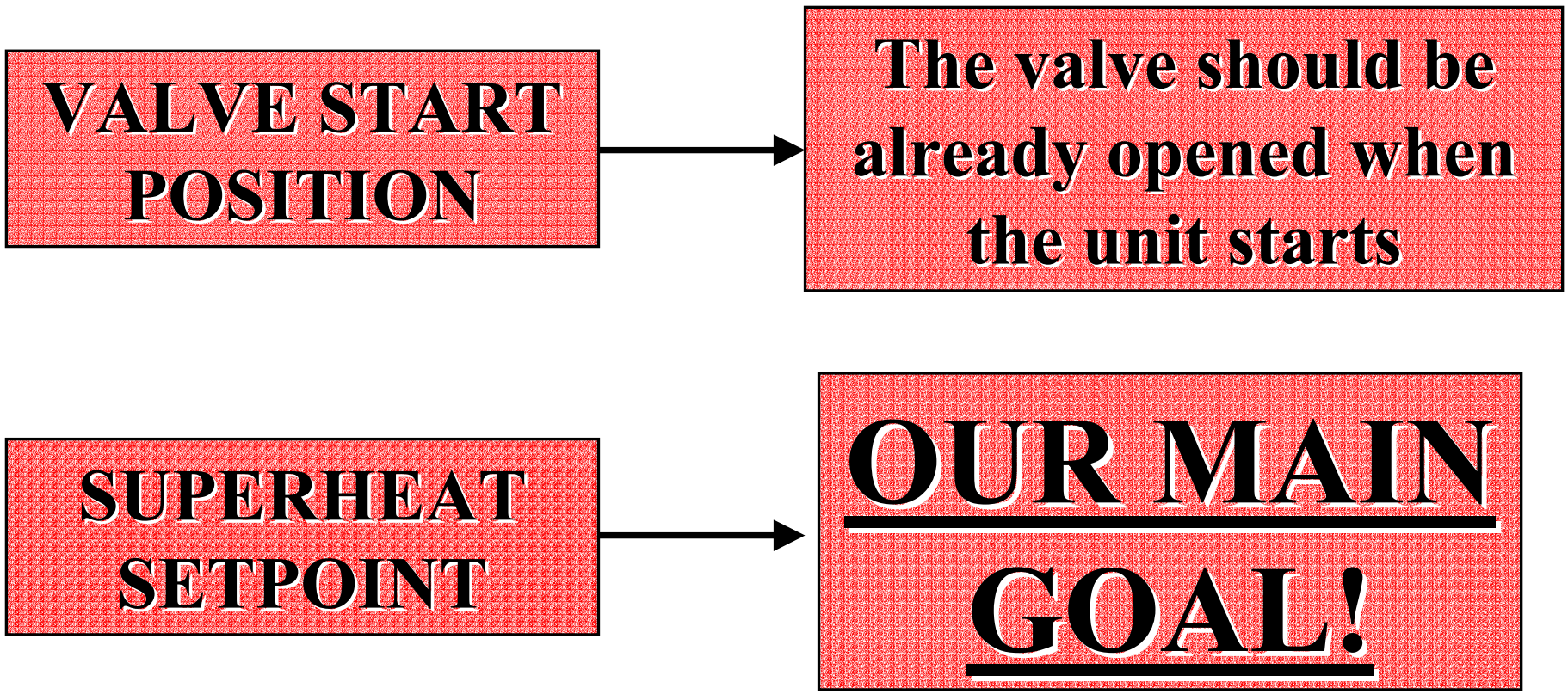
PRESSURE PROBE RANGE

Check the pressure range on the probe label

<u>WRONG pressure probe range values</u>:

- WRONG SUPERHEAT
- WRONG evaporating pressure
- WRONG evaporating temperature

Fondamental parameters: VALVE START POSITION and SUPERHEAT SETPOINT



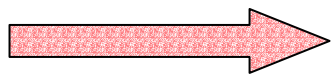
Fondamental OUTPUTS

Driver main outputs

- VALVE POSITION
- SUPERHEAT

Driver probes

- SUCTION TEMPERATURE
- EVAPORATIONG PRESSURE



EVAPORATING temperature

R134a

pCO probe

CONDENSING PRESSURE

CONDENSING temperature

Fondamental OUTPUTS: typical values

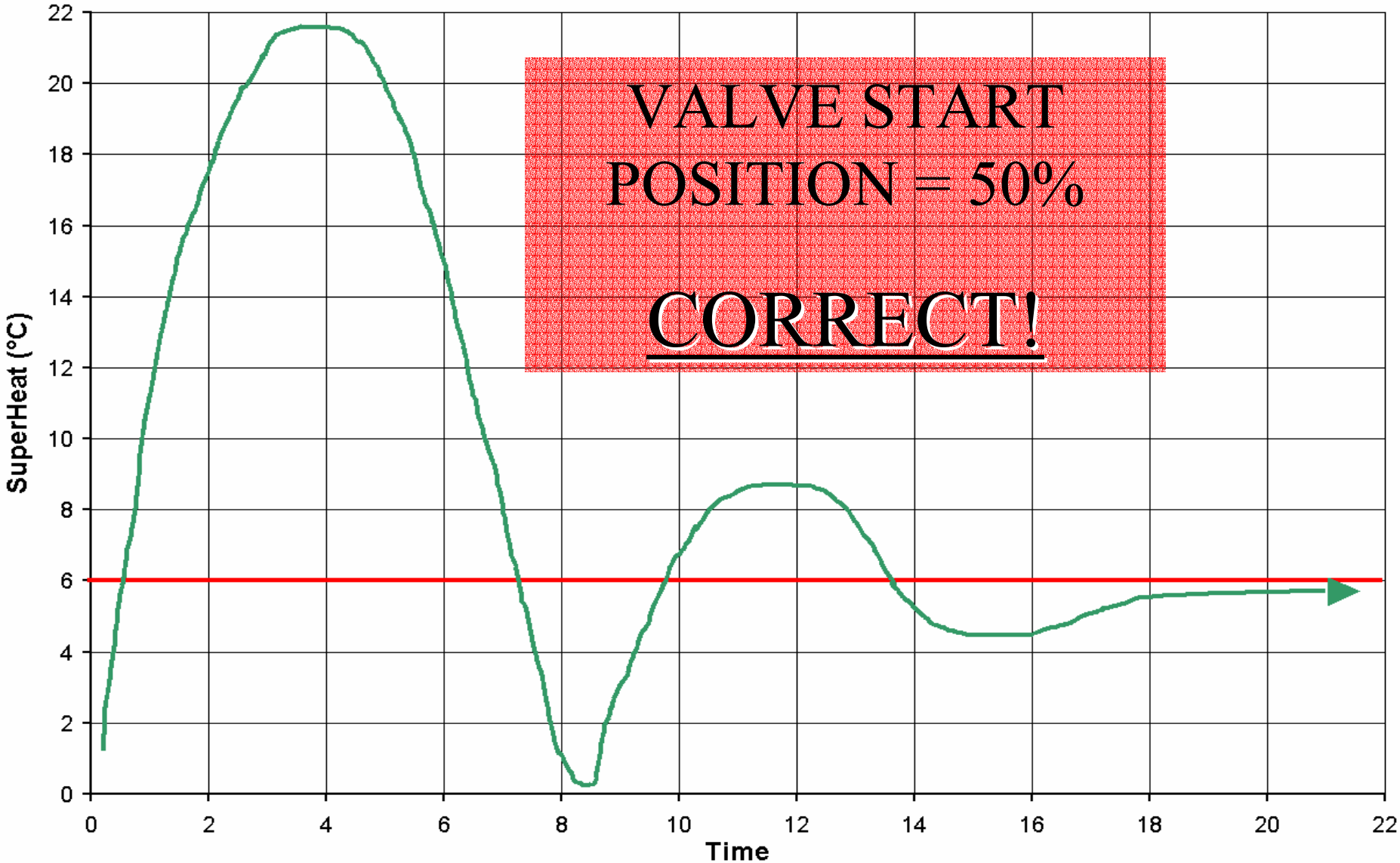
Conditioning R407c	
Condensing pressure	17 barg
Evaporating pressure	3.9 barg
Condensing temperature	45 °C
Evaporating temperature	2°C
Suction temperature	7°C
SUPERHEAT	**5 °C**

You can check the refrigerant type

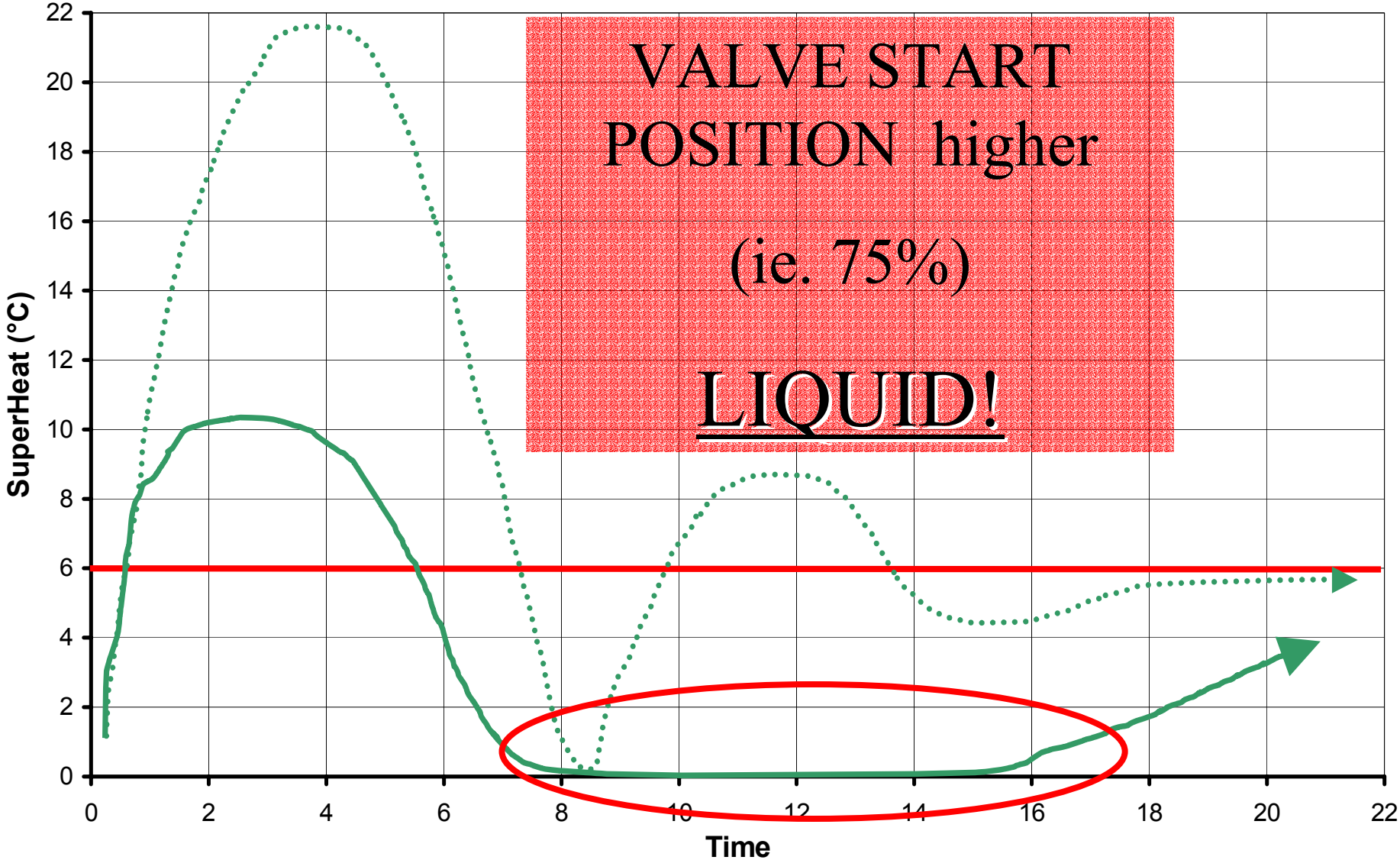
Refrigeration R404a	
Condensing pressure	15 barg
Evaporating pressure	0.5 barg
Condensing temperature	35 °C
Evaporating temperature	- 38°C
Suction temperature	- 32°C
SUPERHEAT	**6 °C**

The difference gives the value of SUPERHEAT

1) START UP of the unit: CORRECT



1) START UP of the unit: LIQUID



1) START UP of the unit: HP/LP switches

VALVE START POSITION highest

(ie. 100%)

LIQUID and HP switch!

VALVE START POSITION lowest

(ie. 10%)

LP switch!

→ The UNIT STOPS!!

1) START UP of the unit: EVENTS

Start position	***The valve is…***	***What happens?***	***The result is…***
100%	Too opened	HP SWITCH	Unit STOPS
75%	Too opened	LOW SUPERHEAT	LIQUID in the compressor
50%	*ok!*	*Correct START*	*None*
10%	Too closed	LP SWITCH	Unit STOPS

1) START UP of the unit

PROBLEM	CONDITIONS	REASONS	ACTION
The SUPERHEAT is at very LOW values (near 0°C) few seconds after the start up	If the DRIVER works properly (1):	the driver parameters for the positioning procedure could be inadequate	check if EEV/CIRCUIT RATIO parameters is too high and set a lower value
		the LOW protection parameters could be inadequate	check if LOW LIMIT parameter is too low and set an higher value
			check if LOW INTEGRAL TIME parameter is too high and set a lower value
		the valve is moving in the wrong direction	check the driver VALVE connections
		the valve could be damaged	replace the valve
...because the valve is TOO OPENED	If the DRIVER did not complete the CLOSING procedure	the valve is not fully closed at the start up of the unit	check VALVE TYPE parameter
			Turn OFF and ON the power supply and check the CLOSING procedure again

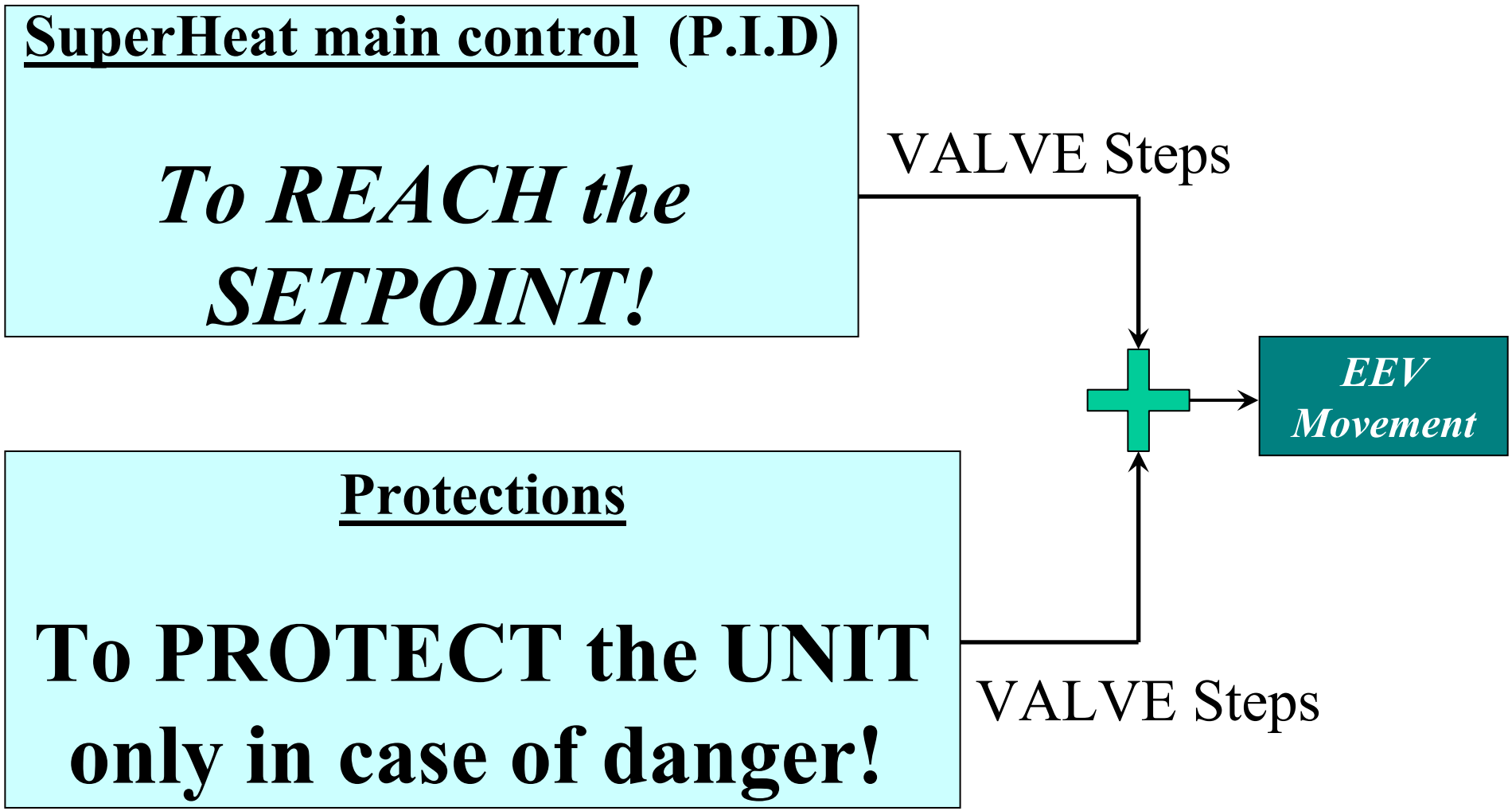
1) START UP of the unit

PROBLEM	CONDITIONS	REASONS	ACTION
LP (low pressure switch) stops the unit after few seconds…	If the DRIVER works properly (1):	the driver parameters for the positioning procedure could be inadequate	check if LOP LIMIT parameter is too low
			check if LOP INTEGRAL TIME parameter is too high
			check if EEV/CIRCUIT RATIO parameters is too low
		the valve could be fouled	remove the valve and check
		the valve could be damaged	replace the valve
…because the valve DOES NOT OPEN PROPERLY	If the DRIVER does not start with the unit in STAND ALONE MODE	the driver does not comunicate with the unit through the DIGITAL INPUT	check the driver FREE CONTACT DIGITAL INPUT (ID, AVss) connection
			check if the STAND ALONE USE parameter is YES
	If the DRIVER does not start with the unit in pLAN MODE	the driver does not receive the START command from the pCO	check if the STAND ALONE USE parameter is NO
	If the DRIVER does not execute the POSITIONING procedure	the driver parameters are not correct	check VALVE TYPE and EEV/CIRCUIT RATIO parameters

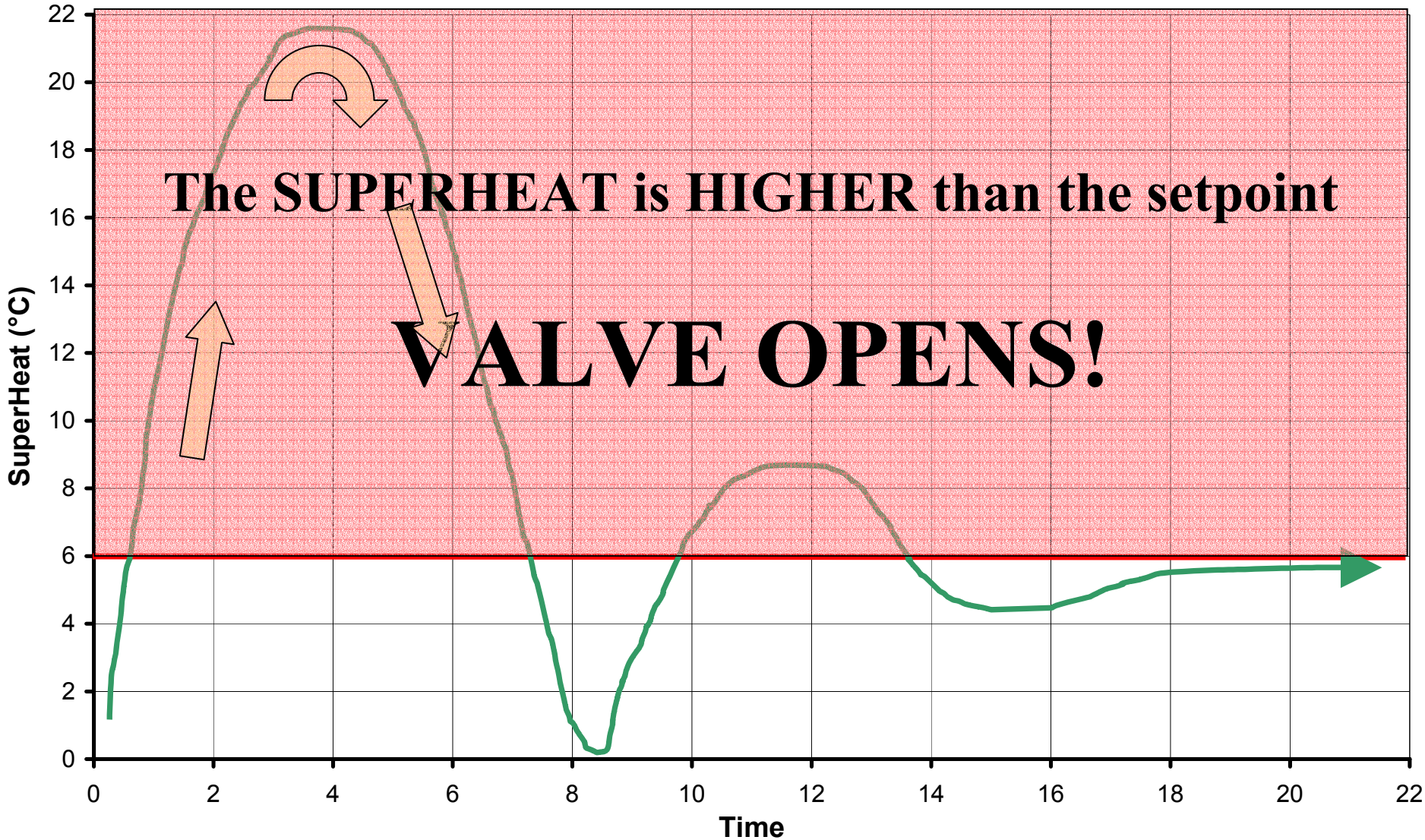
1) START UP of the unit

PROBLEM	CONDITIONS	REASONS	ACTION
HP (high pressure switch) stops the unit after few seconds…	If the DRIVER works properly (1):	the driver parameters for the positioning procedure could be inadequate	check if EEV/CIRCUIT RATIO parameters is too high and set a lower value
		the valve is moving in the wrong direction	check the driver VALVE connections
		the valve could be damaged	replace the valve
...because the valve is TOO OPENED	If the DRIVER did not complete the CLOSING procedure	the valve is not fully closed at the start up of the unit	check VALVE TYPE parameter
			Turn OFF and ON the power supply and check the CLOSING procedure again

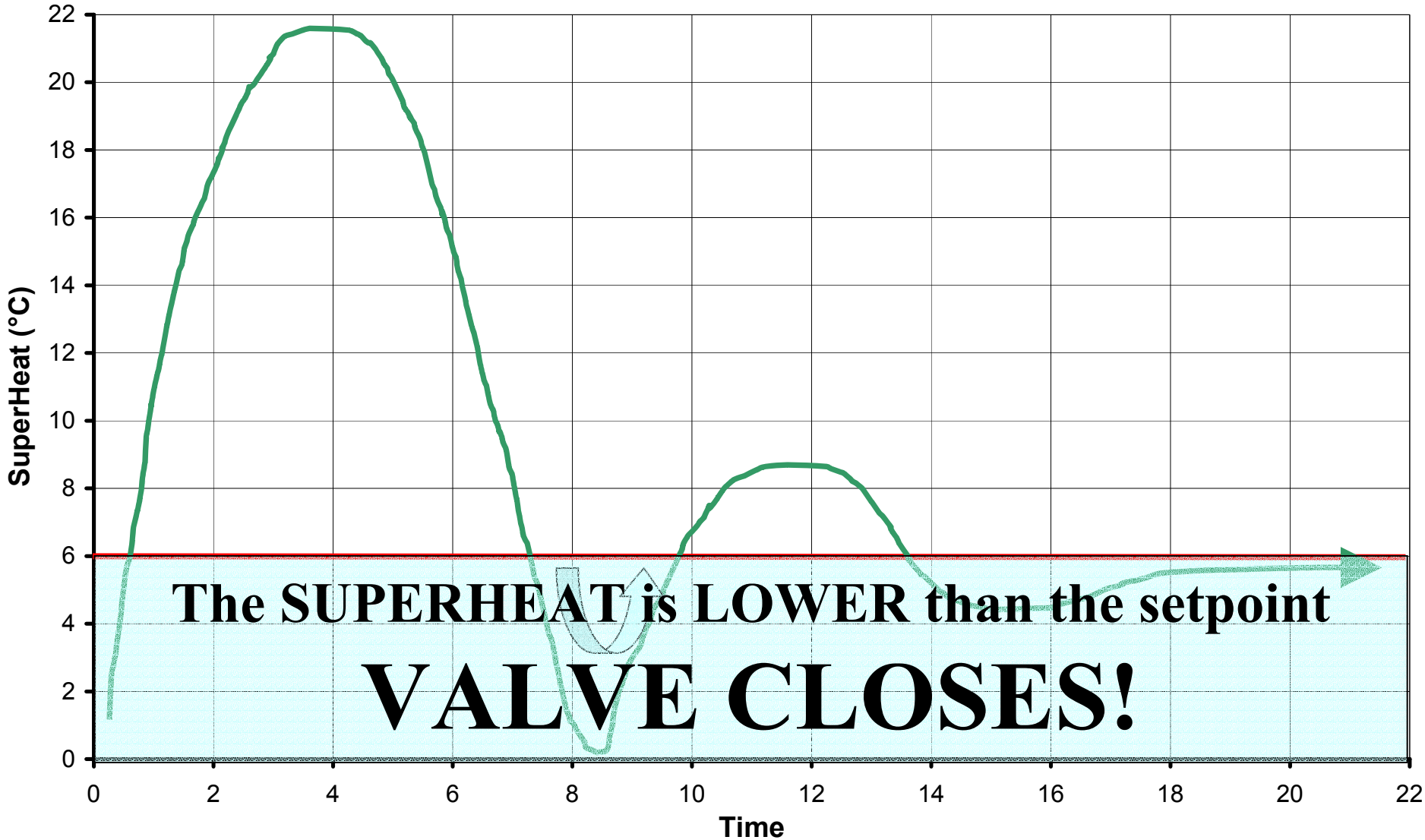
Valve Control Algorithm



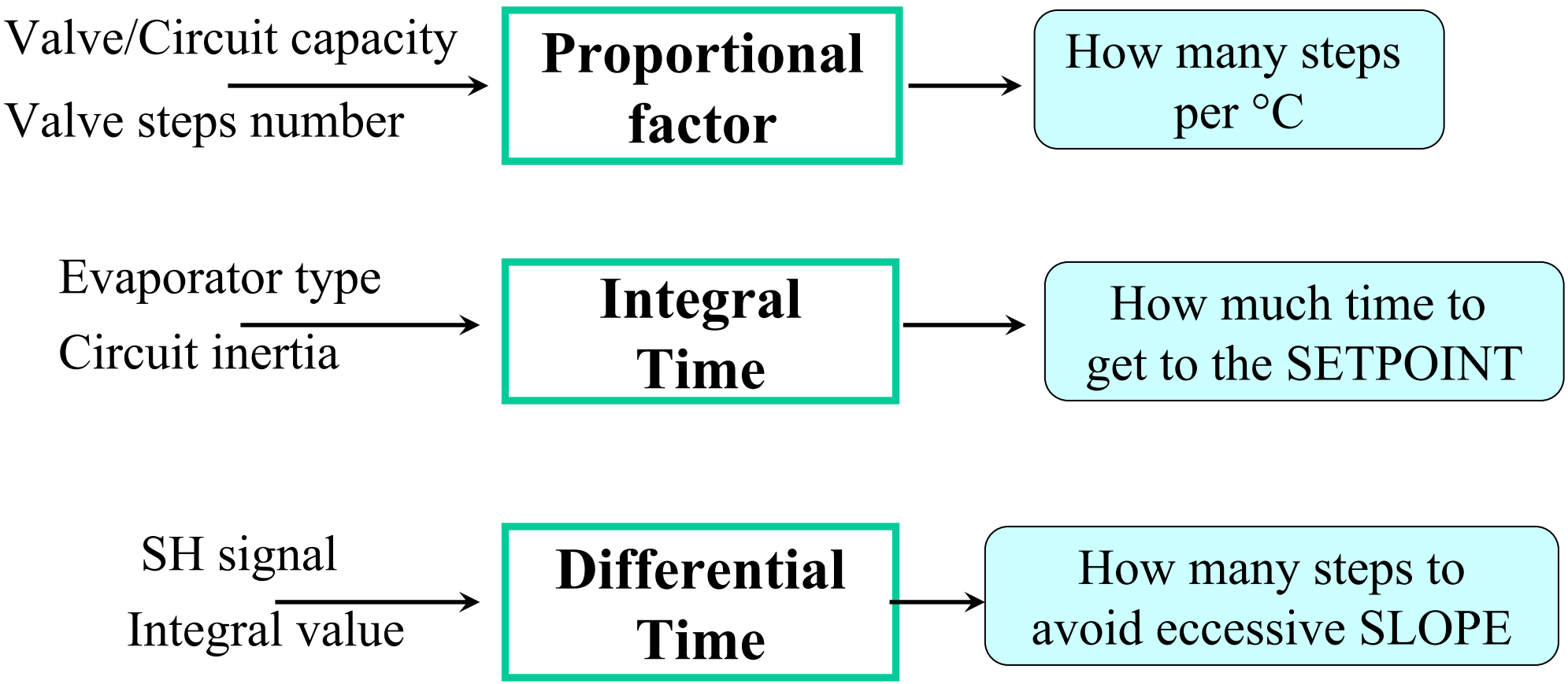
Valve Control Algorithm



Valve Control Algorithm



P.I.D. - SuperHeat control algorithm



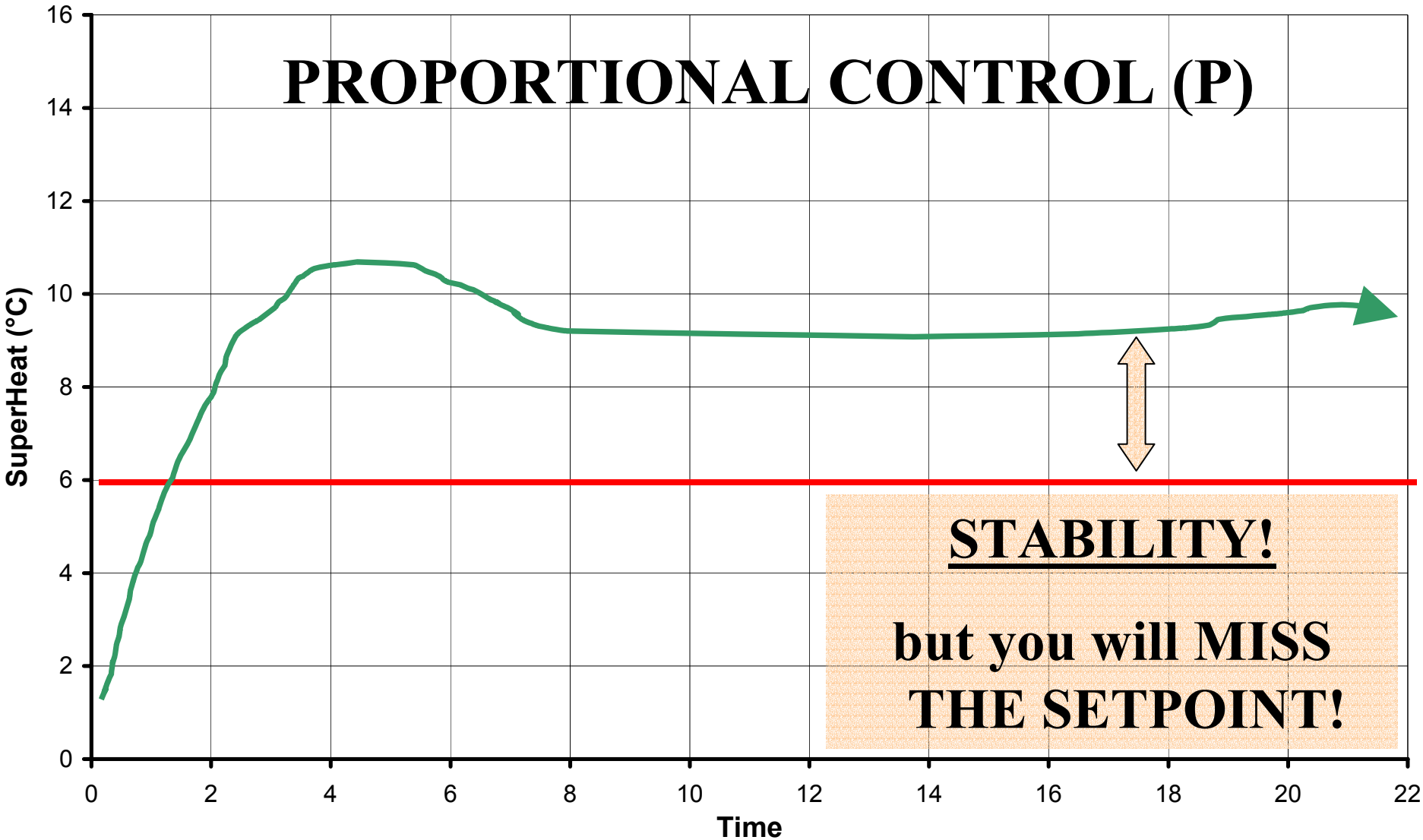
P.I.D. - SuperHeat control algorithm

High values of Kp →
- Greater valve speed
- Greater reaction of all protections

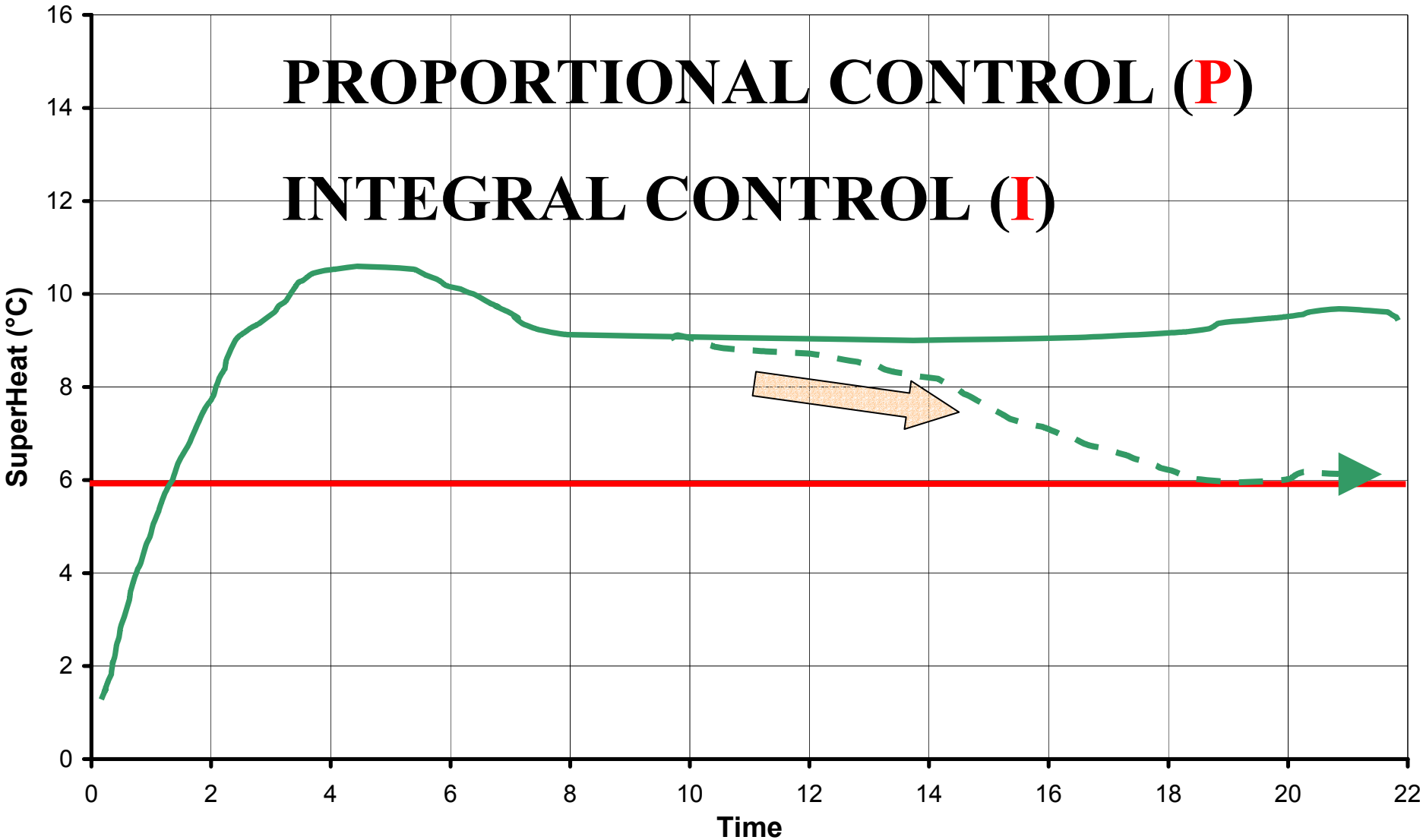
High values of Integr Time →
- Valve slower to get to the SETPOINT
- Less HUNTING

High values of Differ Time →
- Avoid HUNTING
- May cause “vibrating” SH accross setpoint
- Valve reacts quickly to SH SLOPE

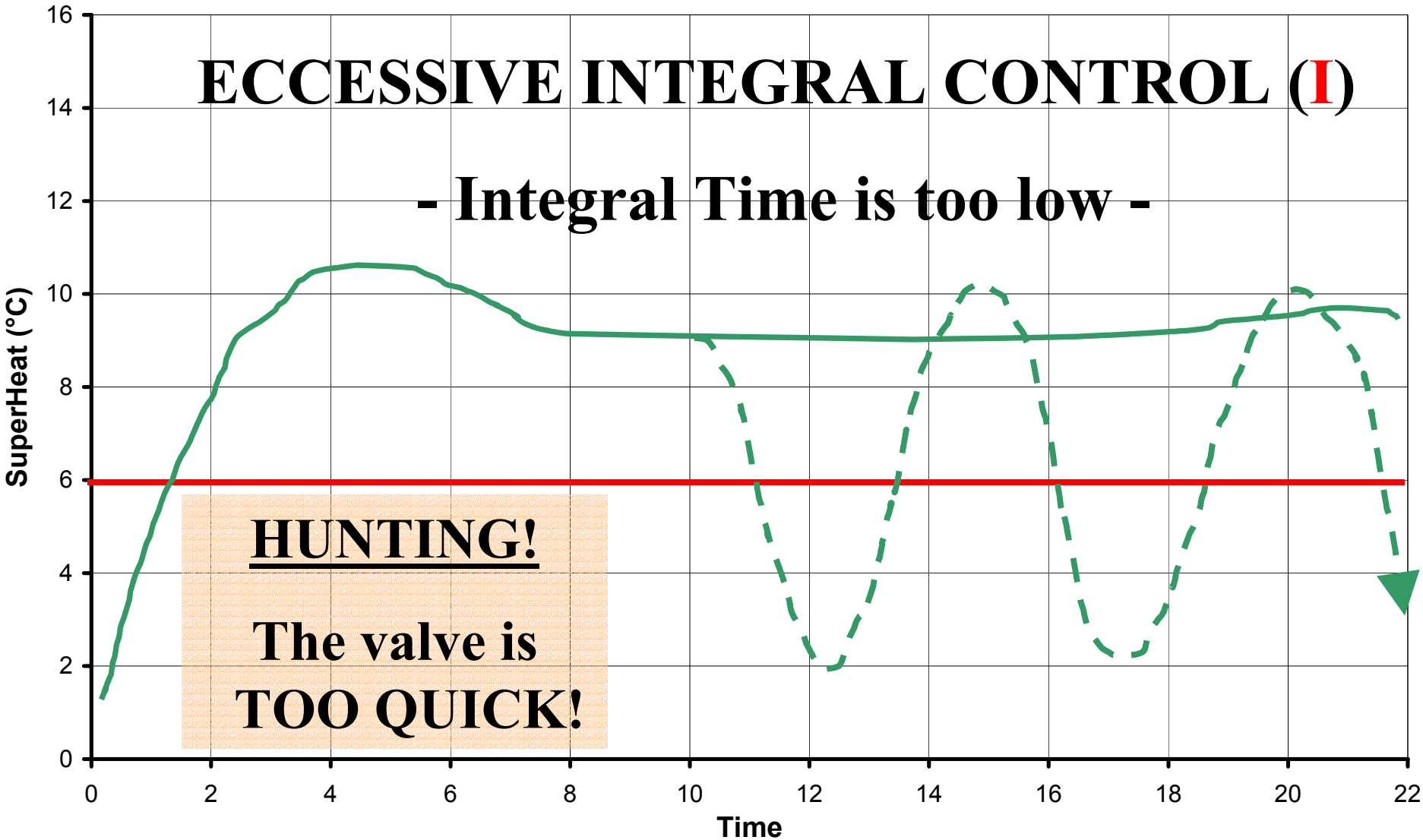
P.I.D. - Proportional control factor



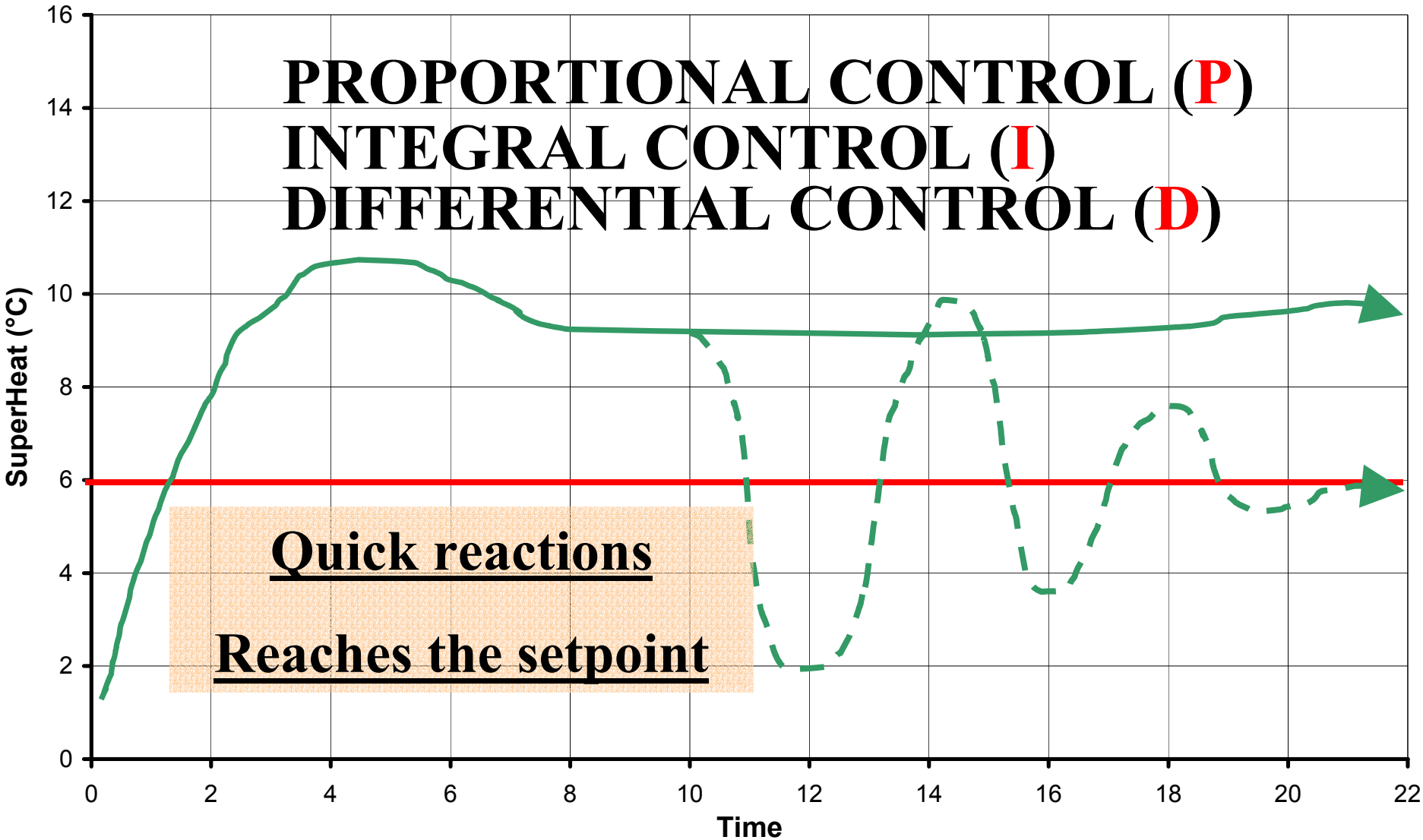
P.I.D. - Proportional / integral control



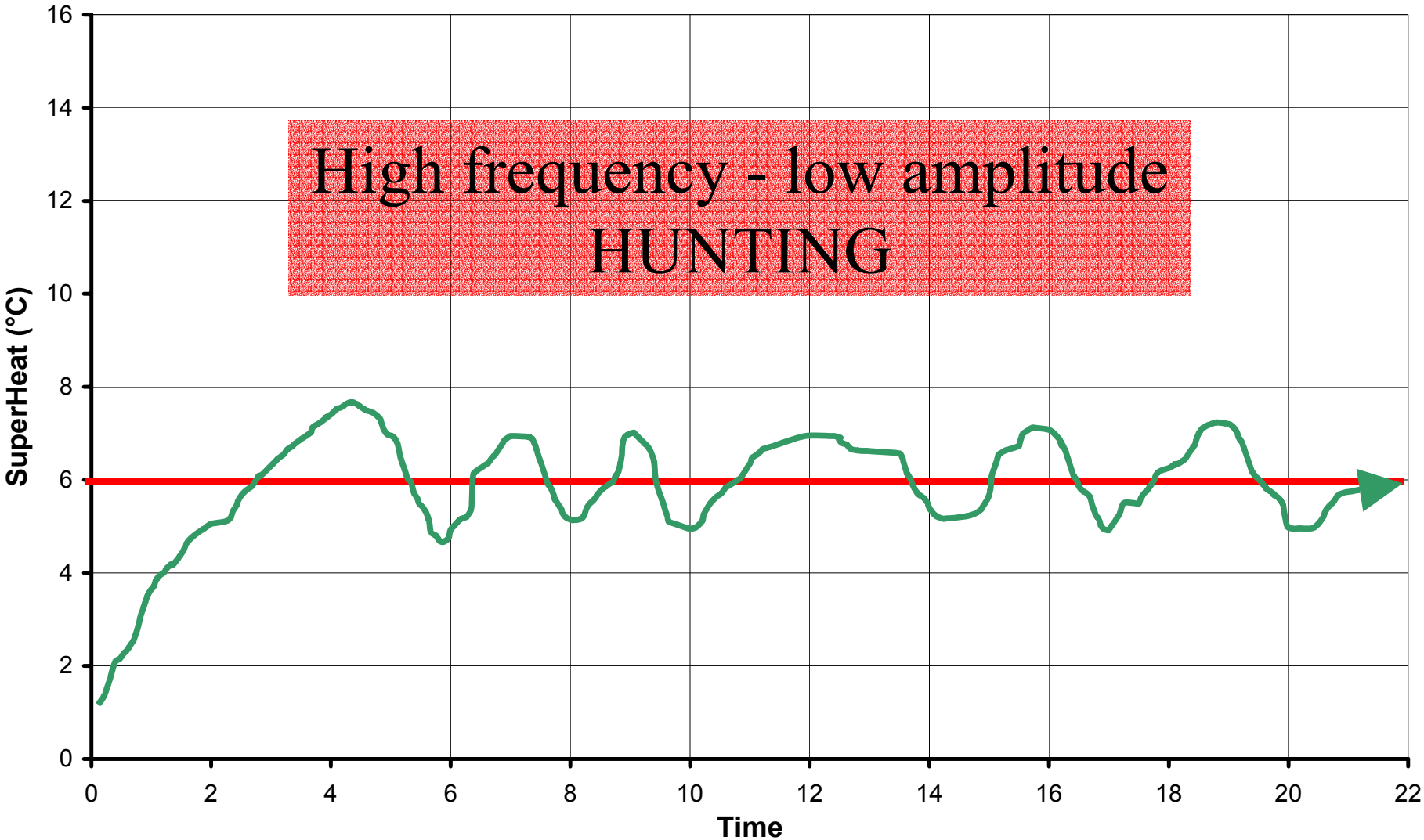
P.I.D. - Proportional / integral control



P.I.D. Control


PROPORTIONAL CONTROL (P)
INTEGRAL CONTROL (I)
DIFFERENTIAL CONTROL (D)
Quick reactions
Reaches the setpoint
SuperHeat (°C)
Time
0
2
4
6
8
10
12
14
16
18
20
22

P.I.D. - Differential control



P.I.D. - Differential control

P.I.D. - Integral time control values

INTEGRAL TIMES parameters values, including protections:
0sec = integral protection/regulation DISABLED
0.1sec = integral protection/regulation at MAXIMUM POWER
>0.1sec = integral protection/regulation at DECREASING POWER
250sec = integral protection/regulation at MINIMUM POWER

P.I.D. - Differential time control values

DIFFERENTIAL TIME PID parameter values:
0sec = differential regulation DISABLED
0.1sec = differential regulation at MINIMUM POWER
>0.1sec = differential regulation at INCREASING POWER
250sec = differential regulation at MAXIMUM POWER

P.I.D. - Easy suggestions for parameters

1) SUPERHEAT SET-POINT should be always between 4 and 8°C
2) LOW LIMIT should be always between 1 and 4°C
3) LOW LIMIT should be 2-4°C lower than the SH setpoint
4) PROPORTIONAL FACTOR increases all valve movements, including all protections
5) INTEGRAL TIME should be higher than 30sec to achieve superheat stability
6) INTEGRAL TIME should be lower than 15sec to achieve valve rapidity in movement
7) DIFFERENTIAL TIME should be enabled (higher than 0sec) only in case of lower INTEGRAL TIME values
8) LOP/MOP LIMITS should be always OUTSIDE the working temperatures of the unit (they are LIMITS never to be reached in normal working conditions)

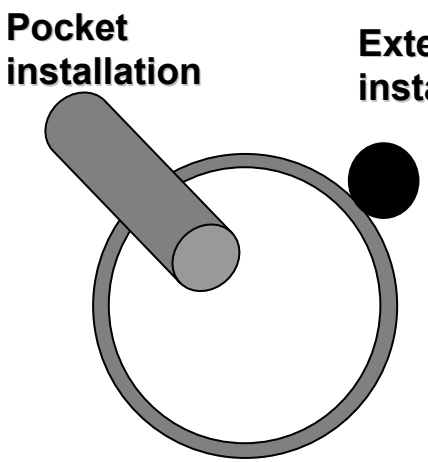
Problems in superheat measurements

PROBLEM	CONDITIONS	REASONS	ACTION
The value of SUPERHEAT is incorrect… …compared to another external correct measurement	If the DRIVER reads temperature and pressure probes correctly	the refrigerant type parameter is wrong	check the REFRIGERANT TYPE parameter
	If the DRIVER does not read the PRESSURE PROBE correctly	the pressure probe is wrongly/not connected	check pressure probe connections
		the pressure probe range parameters are wrong	check if the pressure probe range parameters are equal to the probe range (see the label on the probe)
		the pressure probe is damaged	replace pressure probe
	If the DRIVER does not read the TEMPERATURE PROBE correctly	the temperature probe is wrongly/not connected	check temperature probe connections
		the temperature probe is damaged	replace temperature probe

Problems in superheat measurements

PROBLEM	*CONDITIONS*	*REASONS*	*ACTION*
The value of SUPERHEAT is only slightly different (max +/- 2°C)…	If the TEMPERATURE PROBE is not precise and positioned EXTERNALLY	the temperature probe is not in the right position	check temperature probe position (1)
	If the PRESSURE PROBE is not precise	the pressure probe is not in the right position	check pressure probe position (1)
…compared to another external correct measurement	If you can NOT MOVE the probes	the measurement of the driver will not be precise	adjust all driver parameters regarding probes and superheat (Setpoint, low limit, LOP limit, etc.) to the real value

Probes position



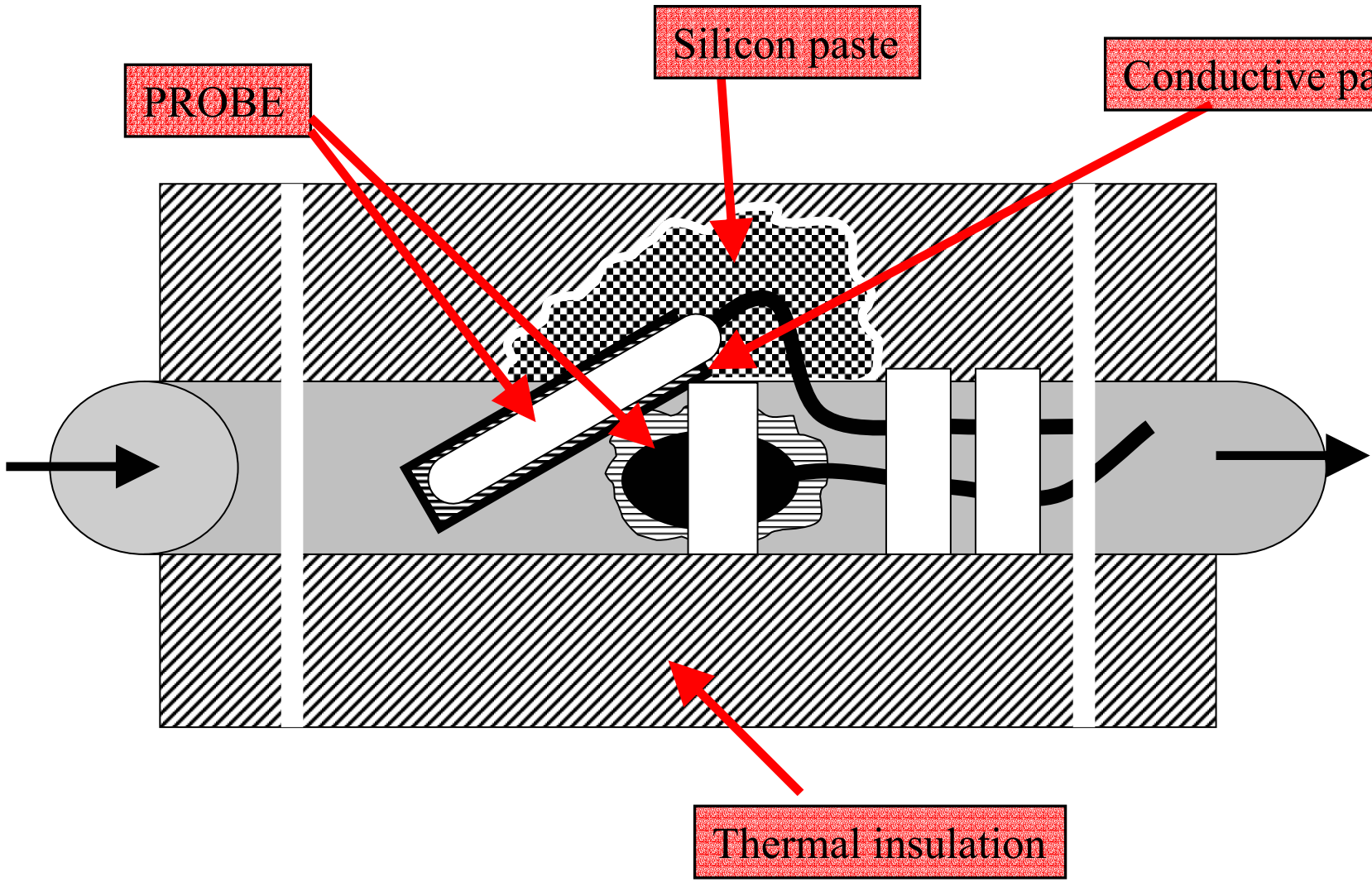
TEMPERATURE PROBE

- As close as possible to evaporator outlet
- Use conductive paste and thermal insulation
- Use an internal poket (gt.Φ4.2mm) if possibile
- At 330° or 30° and before vertical lines if any

PRESSURE PROBE

- As close as possible to temperature probe
- With or without capillary tube
- Chose the minimum possible range

Temperature probe insulation



Problems in superheat regulation

PROBLEM	*CONDITIONS*	*REASONS*	*ACTION*
The SUPERHEAT is permanently at very LOW values (near 0°C)...	If the DRIVER works properly (1):	the valve is moving in the wrong direction	check the driver VALVE connections
		the valve could be damaged	replace the valve
… and you can see LIQUID in the compressor sight glass if any	If DRIVER opening/closing LEDS are both fixed OFF	the driver PID parameters are wrong (ie. Proportional factor could be too low)	check driver PID parameters

Problems in superheat regulation

PROBLEM	*CONDITIONS*	*REASONS*	*ACTION*
The SUPERHEAT is permanently at HIGH values (>20°C)...	If the DRIVER works properly (1):	the subcooling is 0°C or lower (you can see bubbles in the sight glass before valve inlet)	there is LACK of REFRIGERANT in the unit, refill is needed
		tha valve is too small for the unit	check valve sizing and eventually replace the valve with a bigger one
… and the unit has a bad cooling efficiency		the valve could be damaged	replace the valve
	If DRIVER opening/closing LEDS are both fixed OFF	the driver PID parameters are wrong	check driver PID parameters

P.I.D. - Superheat hunting

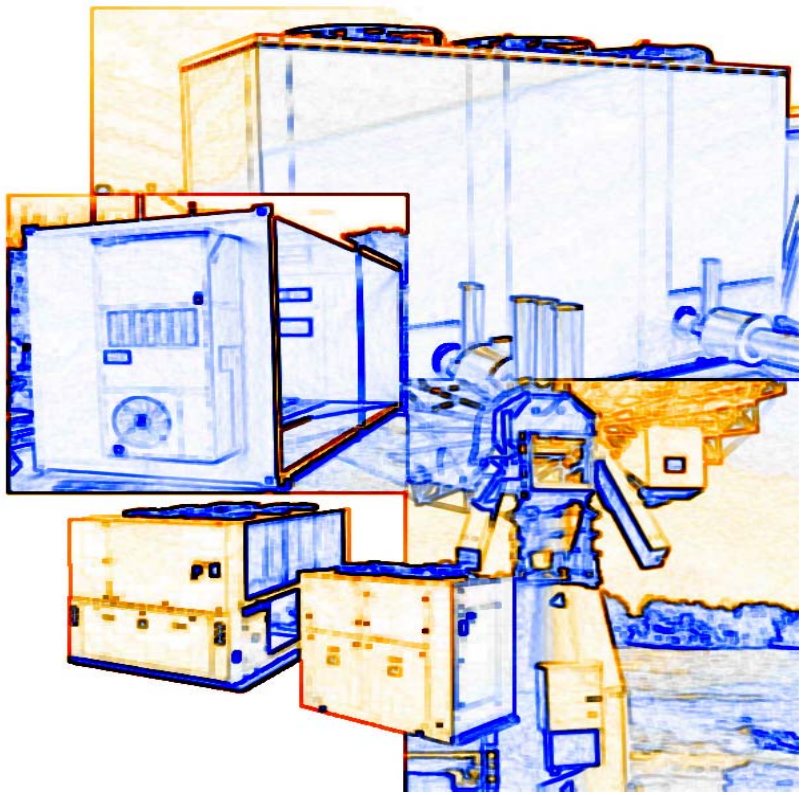
PROBLEM	CONDITIONS	REASONS	ACTION
The SUPERHEAT is permanently HUNTING around the setpoint	The hunting AMPLITUDE is large (+/- 5°C around the setpoint) and all protections are NOT working	the INTEGRAL TIME PID parameter is too low	check INTEGRAL TIME PID parameter and set an higher value
		the PROPORTIONAL FACTOR PID parameter is too high	check PROPORTIONAL FACTOR PID parameter and set a lower value
		the DIFFERENTIAL TIME PID parameter is too high	check DIFFERENTIAL TIME PID parameter and set a lower value
		the SUPERHEAT SET POINT parameter is too low	check the setpoint parameter and set an higher value
	The hunting AMPLITUDE is large (+/- 5°C around the setpoint) and the LOW SUPERHEAT PROTECTION continuately works	the SUPERHEAT SET POINT parameter value is too close to the LOW LIMIT parameter value	check the setpoint parameter and set an higher value or set the LOW LIMIT parameter to a lower value
	The hunting AMPLITUDE is large (+/- 5°C around the setpoint) and the LOP PROTECTION continuately works	the LOP LIMIT parameter is wrong	check the LOP LIMIT parameter and set it to a lower value if possible
		the LOP LIMIT parameter is too close to the unit working evaporating temperature	check if the unit is working with an incorrect evaporating temperature (not expected during design)
			set a LOP LIMIT parameter value adequate (lower) to the actual evaporating temperature

P.I.D. - Superheat hunting

PROBLEM	*CONDITIONS*	*REASONS*	*ACTION*
The SUPERHEAT is permanently HUNTING around the setpoint	The hunting AMPLITUDE is small (+/- 1°C around the setpoint) and with high frequency	the DIFFERENTIAL TIME PID parameter is too high	check DIFFERENTIAL TIME PID parameter and set a lower value
		The probe signals could be disturbed by electrical cables, power suppliers, etc.	check probes cable
	The hunting AMPLITUDE is small (+/- 1°C around the setpoint) and with low frequency	It could be a "normal" hunting in the unit working behaviour	WE SUGGEST YOU to check the unit cooling efficiency: it will be probably costant without hunting, so the SUPERHEAT hunting is not affecting it
		The PID parameters could be better regulated	check and regulate the PID parameters

- E²V training course -

Advanced setup
for Air conditioning and High-end Refrigeration



Protection functions

When does a protection starts? →

Protection Limit

BUT there are RESTRICTING CONDITIONS!

How stronger is valve reaction? →

1) Kp

(higher value = stronger)

2) Protection integral time

(lower value = stronger)

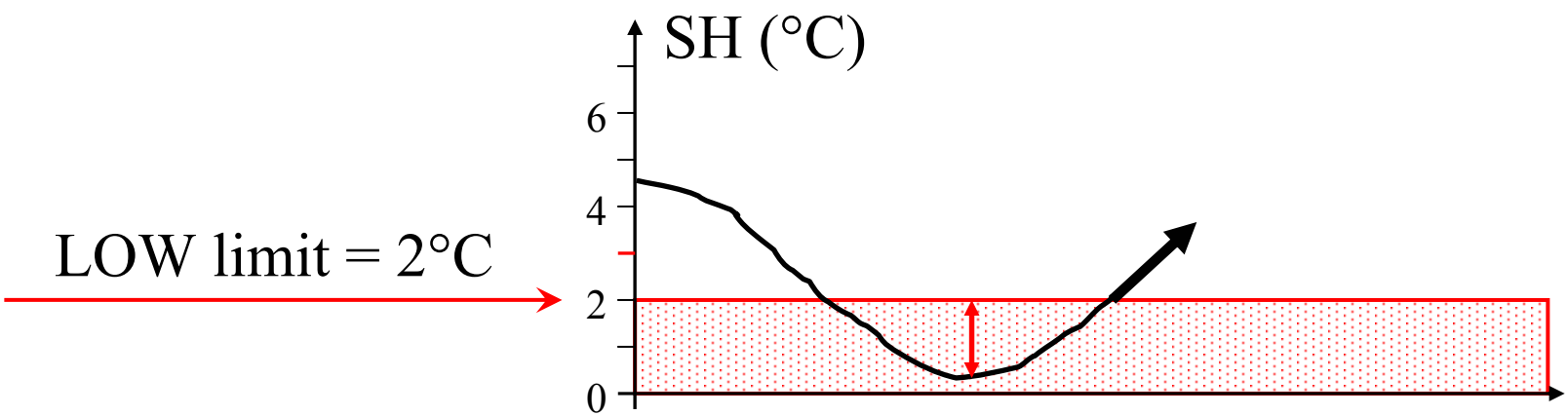
LOW SuperHeat protection

When…

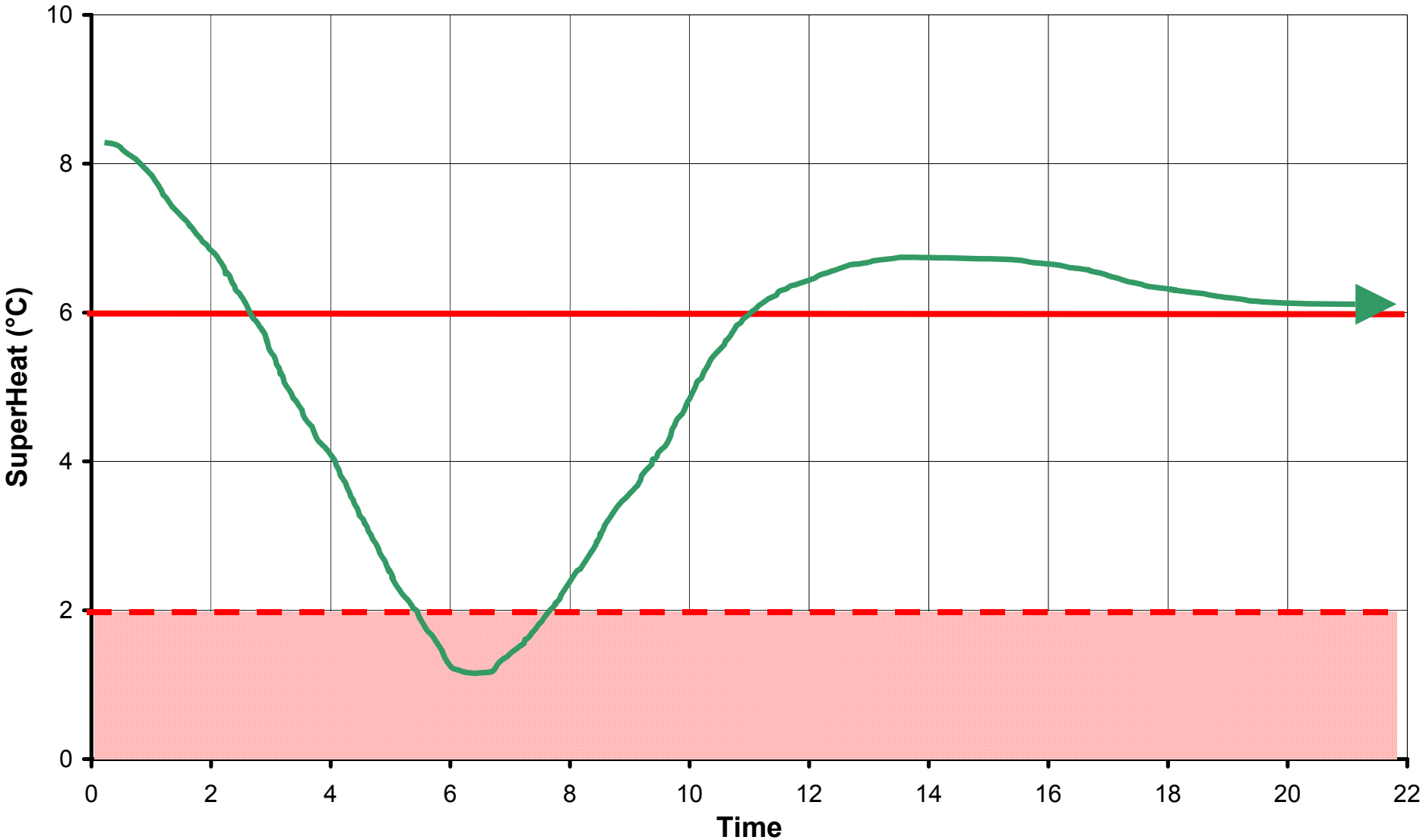
…the valve will…

the SuperHeat goes below the LOW limit (es. 2°C) → CLOSE to increase the SH

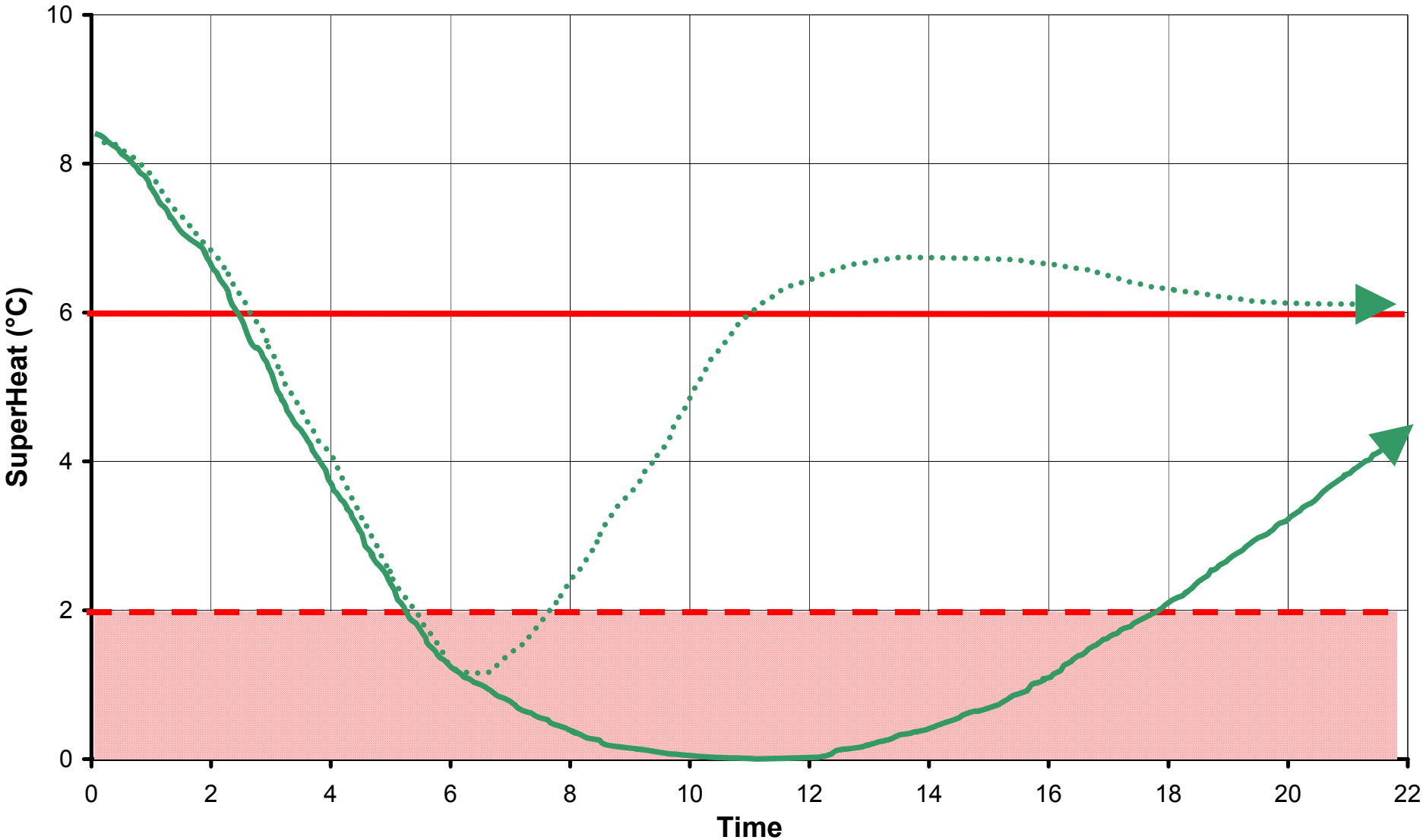
RESTRICTING CONDITION:
NONE



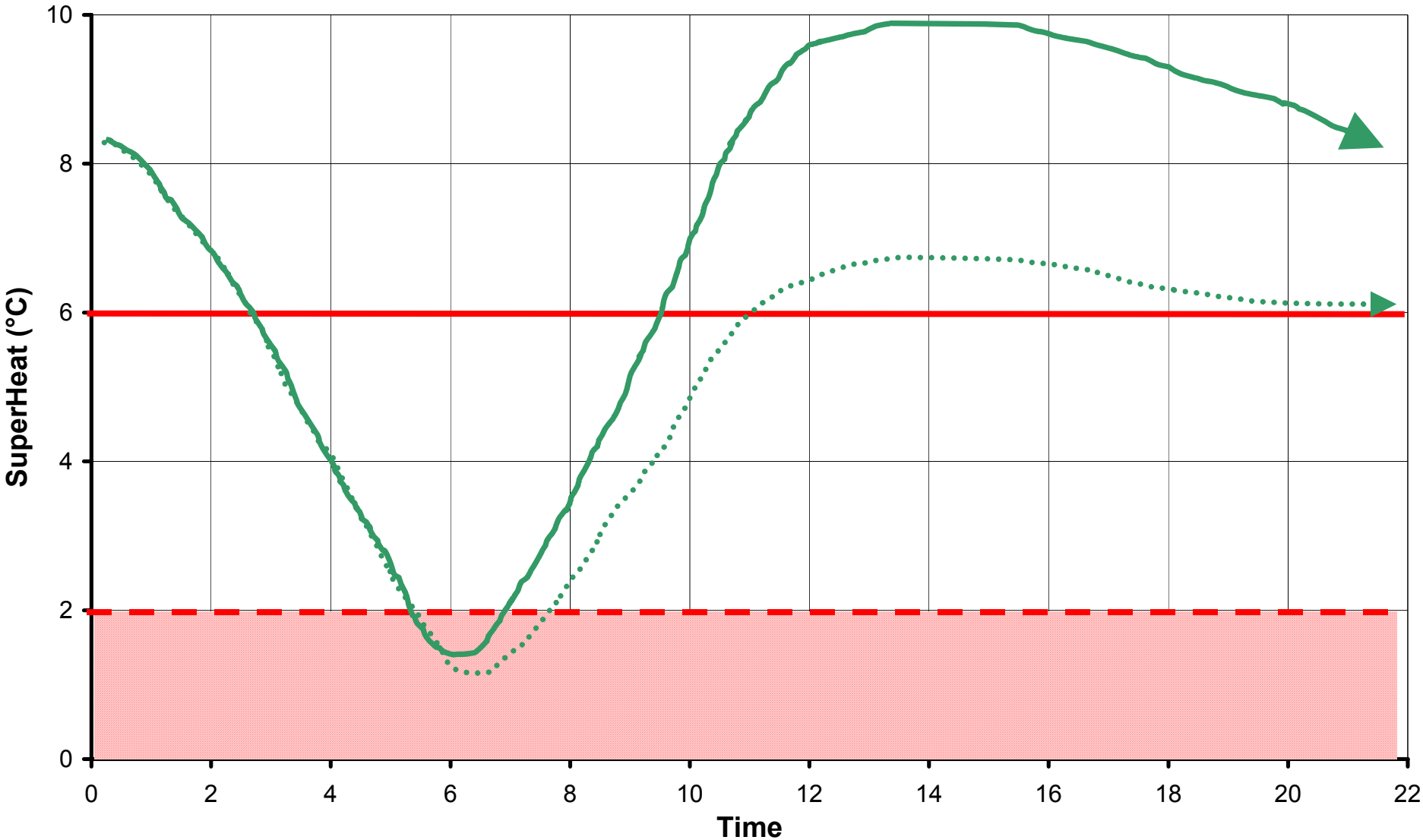
LOW SuperHeat protection



LOW SuperHeat protection



LOW SuperHeat protection



LOW SuperHeat protection

PROBLEM	*CONDITIONS*	*REASONS*	*ACTION*
LOW protection doesn't work…	LOW protection seems not to be enabled or it is useless	LOW INTEGRAL TIME parameter is set to 0sec (protection disabled)	set LOW INTEGRAL TIME parameter at a value higher than 0sec
		LOW INTEGRAL TIME parameter could be too high	set LOW INTEGRAL TIME parameter at a lower value in order to increase protection power

LOP protection

When…

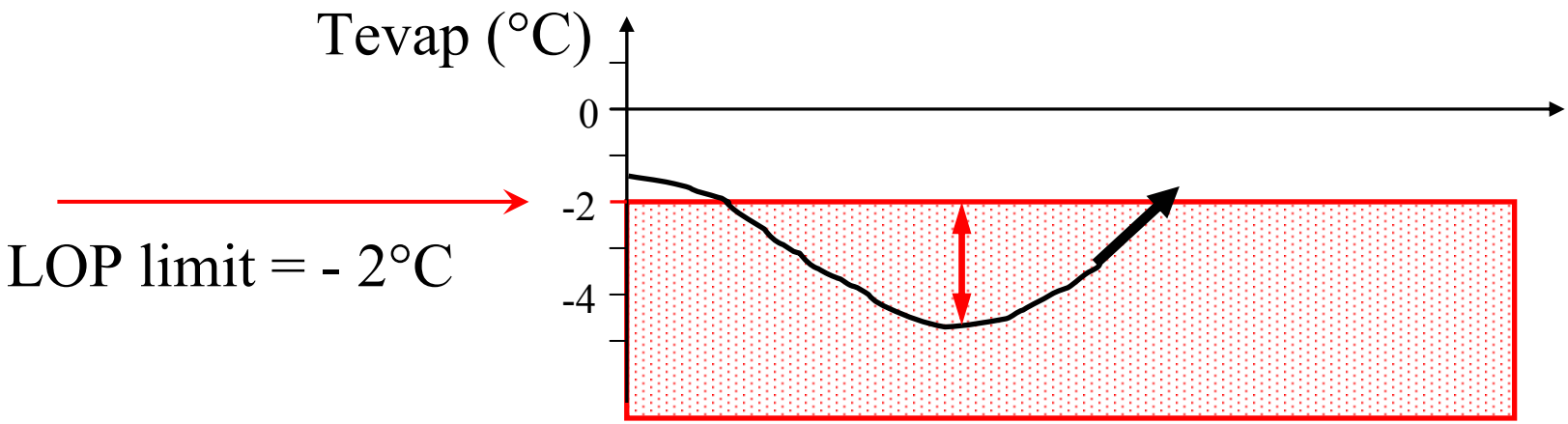
…the valve will…

the Evaporating Temperature goes below the LOP limit → OPEN to increase the pressure

RESTRICTING CONDITION:

Only if the SH is far from LOW limit

(you can not open the EEV and flood the evaporator!)



LOP protection

PROBLEM	CONDITIONS	REASONS	ACTION
LOP protection doesn't work…	LOP protection seems not to be enabled	LOP INTEGRAL TIME parameter is set to 0sec (protection disabled)	set LOP INTEGRAL TIME parameter at a value higher than 0sec
		LOP LIMIT parameter is set at a value lower than the unit low pressure switch, so the switch operates before the driver protection	check the pressure limit value of the LP switch of the unit, calculate the equivalent saturated temperature and set LOP LIMIT parameter at an higher value
...the unit stops for LOW PRESSURE switch	LOP protection operates but it is useless	LOP INTEGRAL TIME parameter could be too high	set LOP INTEGRAL TIME parameter at a lower value in order to increase protection power
		LOP LIMIT parameter is set at a value too close to the unit low pressure switch.	set LOP LIMIT parameter at an higher value if allowed (this value has to be ALWAYS lower than the evaporating temperature of the unit in working conditions)

MOP protection

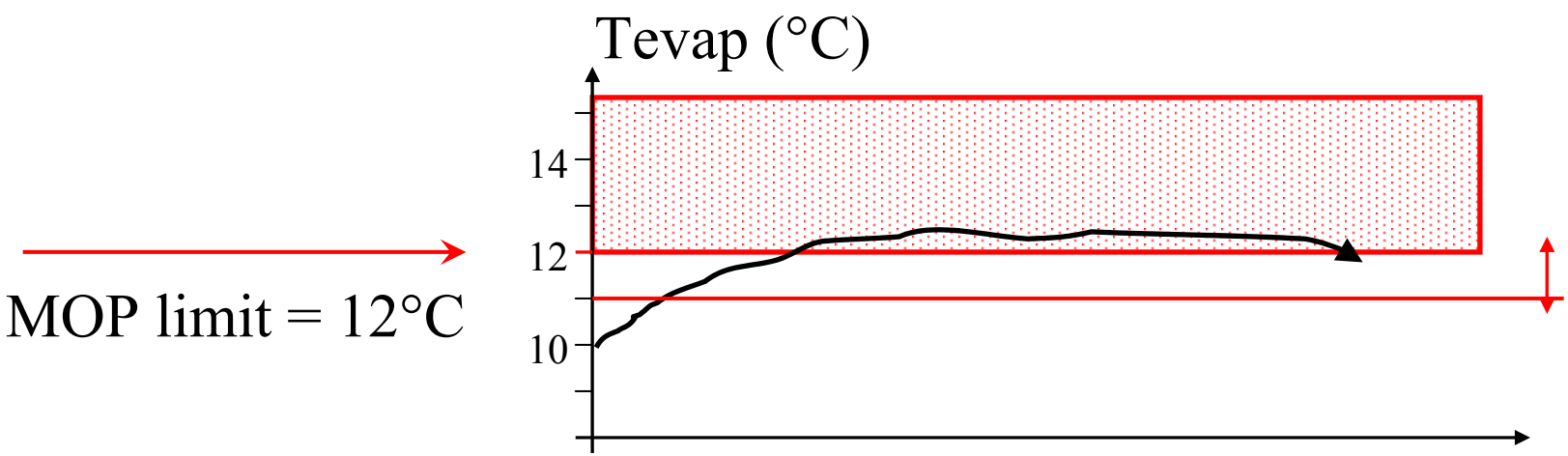
When…

…the valve will…

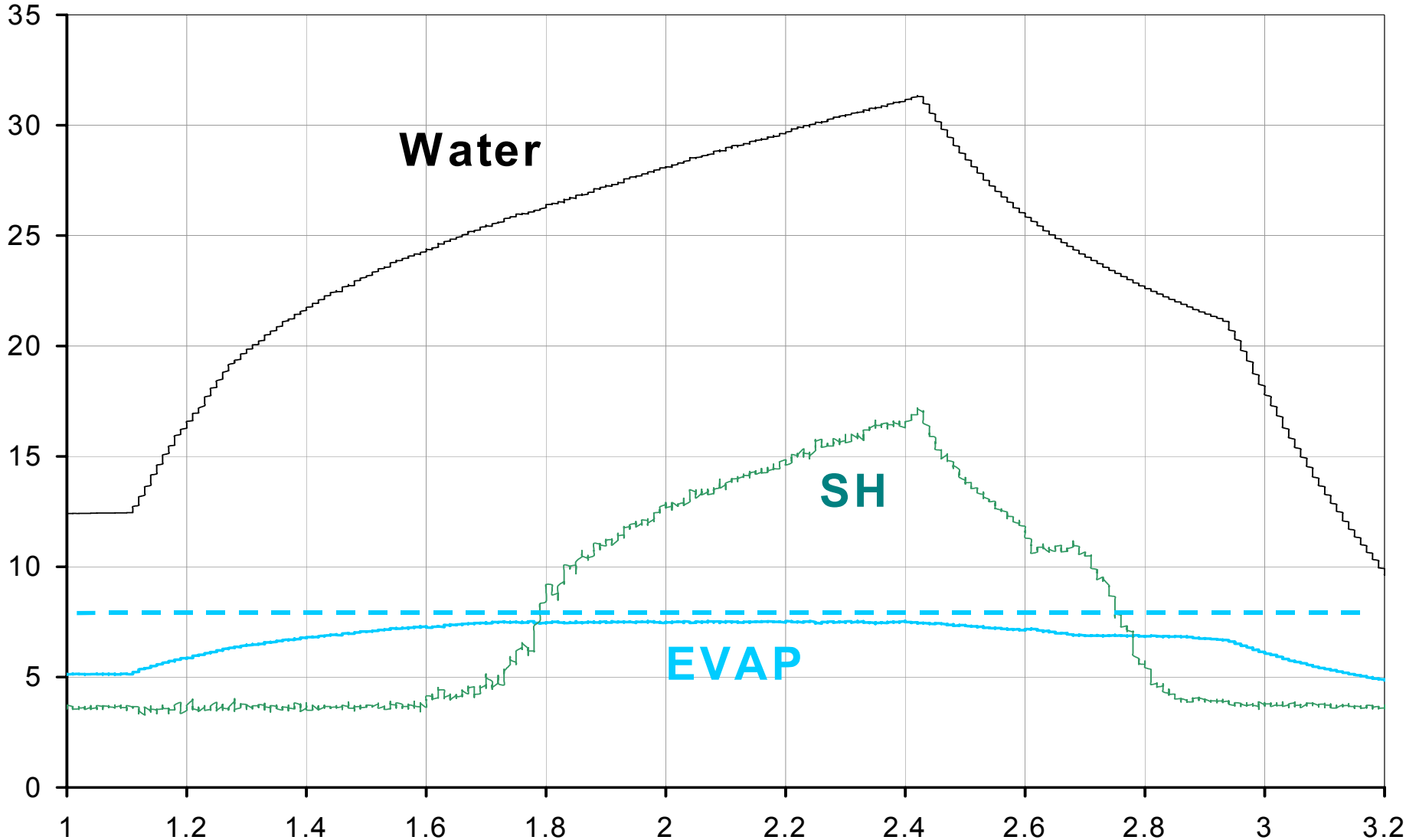
the Evap Temperature goes above the MOP limit (es. 12°C) → CLOSE to decrease the pressure

RESTRICTING CONDITION:

Only if the suction temperature is under the limit (valve closing can cause suction gas to get too hot!)



MOP protection example



MOP protection

PROBLEM	CONDITIONS	REASONS	ACTION
MOP protection doesn't work…	MOP protection seems not to be enabled or it is useless	MOP INTEGRAL TIME parameter is set to 0sec (protection disabled)	set MOP INTEGRAL TIME parameter at a value higher than 0sec
		MOP INTEGRAL TIME parameter could be too high	set MOP INTEGRAL TIME parameter at a lower value in order to increase protection power
SUPERHEATvalue is costantly higher than the setpoint during MOP protection	During MOP protection the superheat leaves the setpoint and start to increase up to 12-15°C	It is the CORRECT PROCEDURE for MOP protection, to decrease pressure you have to allow an higher superheat	NONE
	After MOP protection the superheat decreases very slowly to the setpoint	It is the CORRECT PROCEDURE for MOP protection, to avoid huntings you can not allow the superheat to reach the setpoint quickly	NONE

HiTcond protection

When…

…the valve will…

the Condensing Temperature goes above the HiTcond limit (es. 60°C) → CLOSE to decrease the Cond. temperature

RESTRICTING CONDITION:

Only if the evaporating pressure is above the LOP limit (valve closing decreases the evap pressure!)