Level Pressure Flow Temperature Liquid Analysis Registration Systems Components Services Solutions

Solar thermal power plant

Endress+Hauser

People for Process Automation

22/09/2010

Lukas Hablützel

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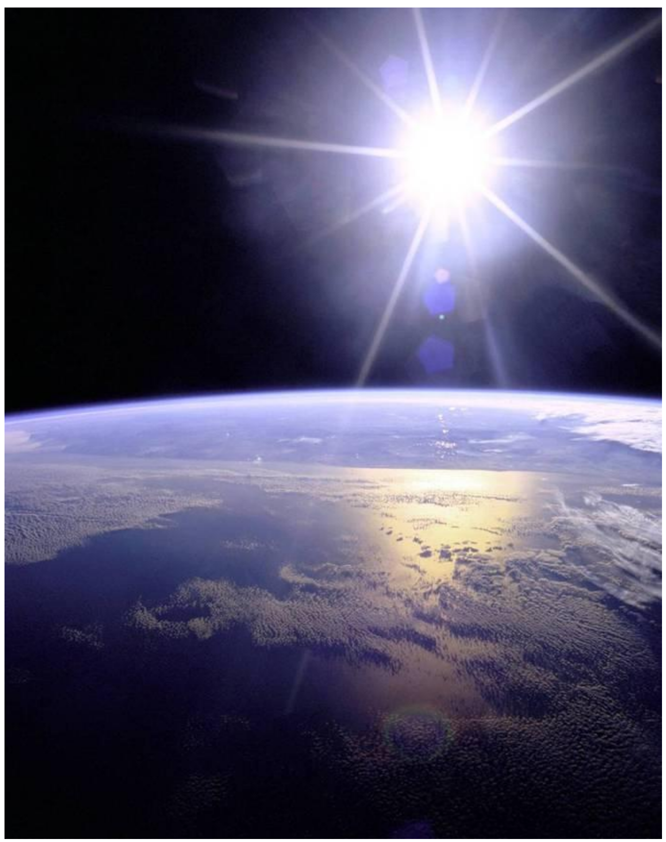
Solar Power – boundless source of energy

Markets, Developments and Key Players



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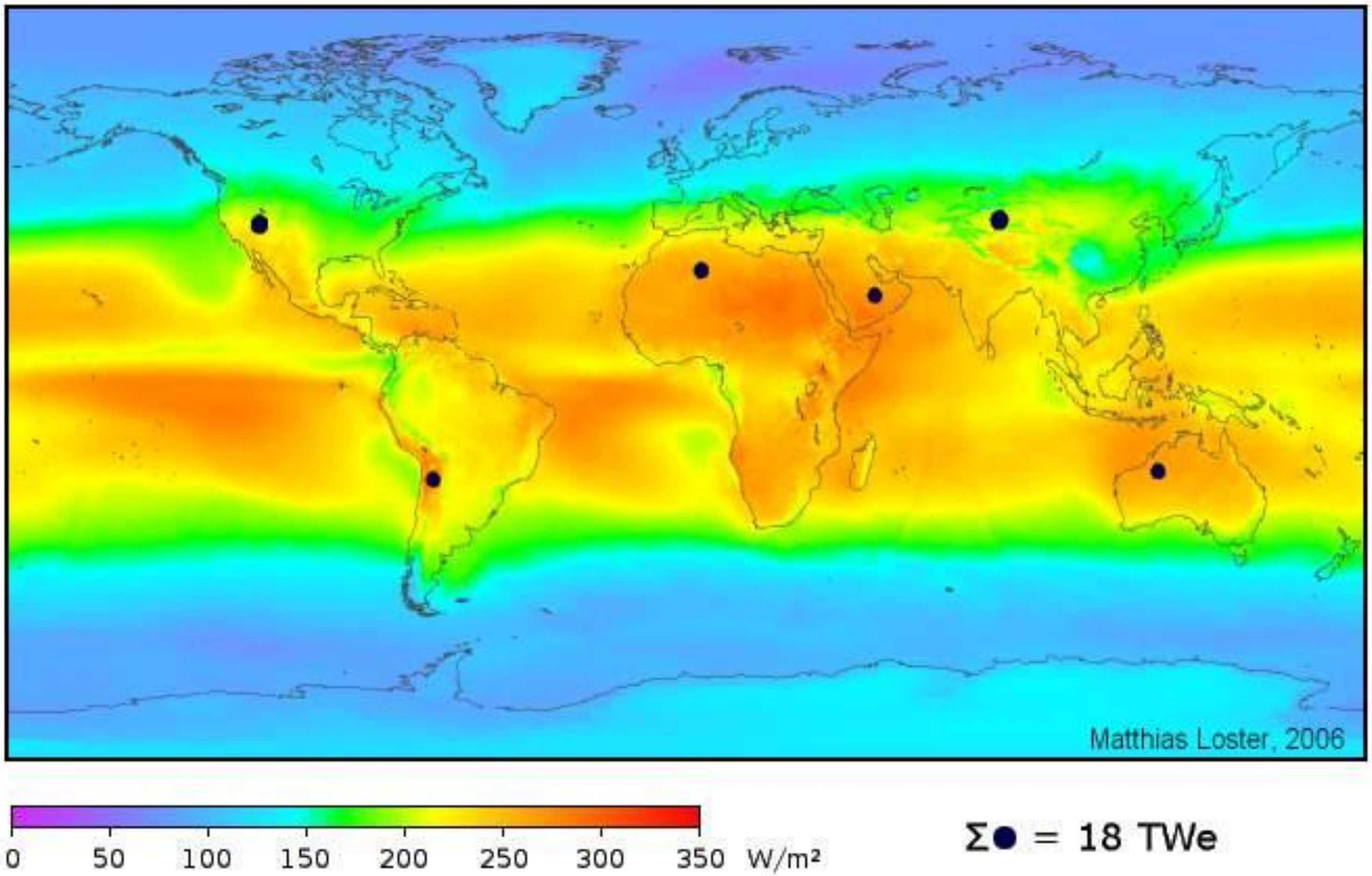
Map of Solar radiation



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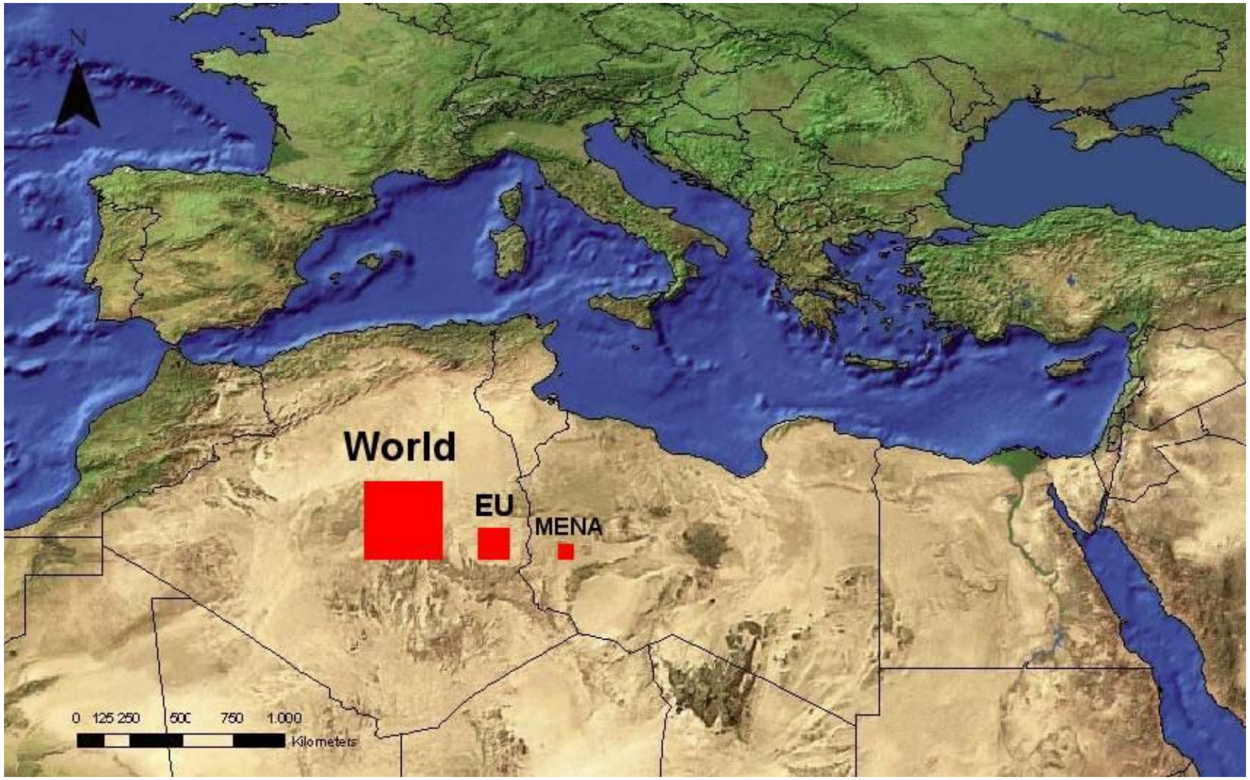
Solar energy – the source of power

Did you know that a square of 500 km could produce more electricity then the world consume is today

$(30MW/km^2) = 7.5TW$



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Solar is rapidly becoming cost competitive

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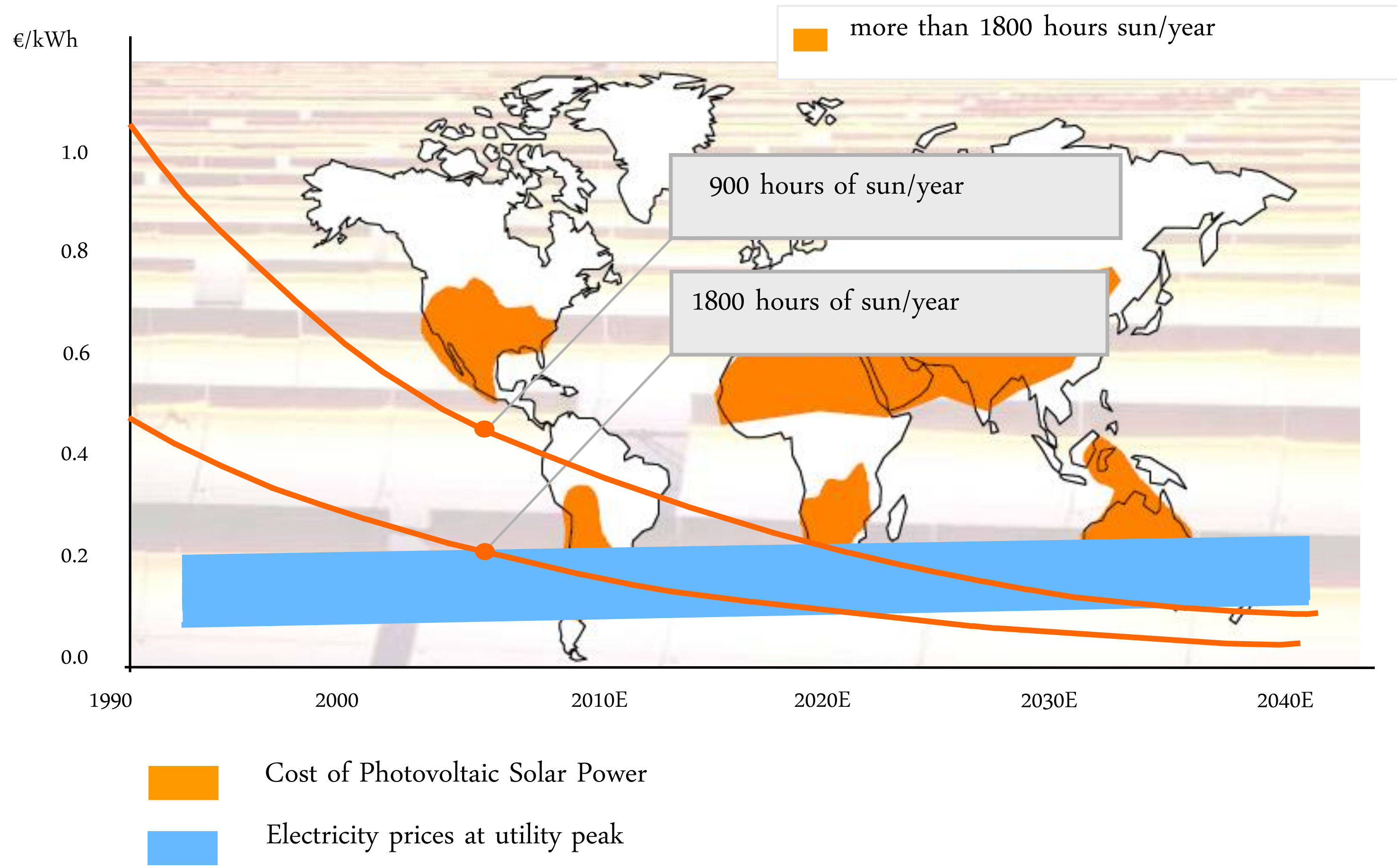

Source: Based in REC and EC Vision Report 2005

ORKLA

Thermal Solar Power plant CSP (Concentrate Solar Power Plant)

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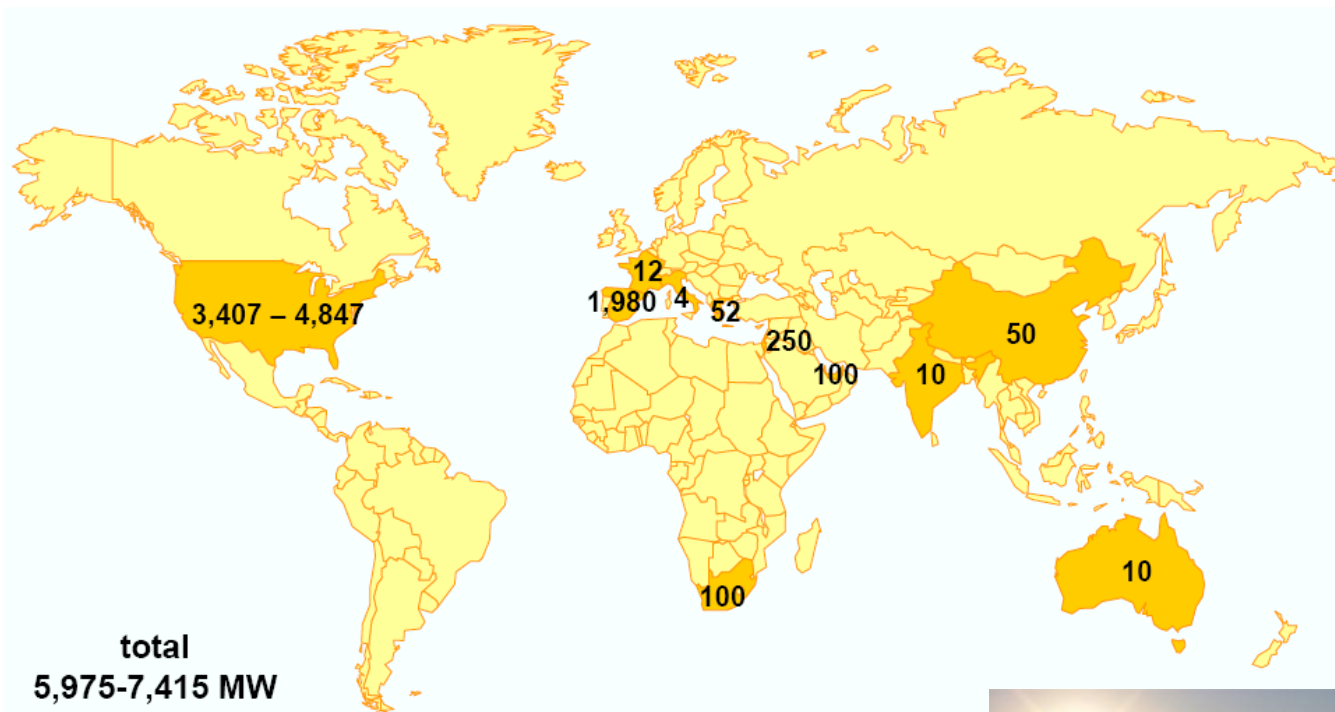
CSP Project Review by Marlene O'Sullivan, DLR, March 2009, REACCESS Project



Announced CSP projects world wide as end of 2008.

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Our Market potential in Thermal Solar Power Plant

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- A typical Thermal Solar Power Plant produces 50-300 MW electricity
- The investment for a 50MW Solar Power Plant (e.g. Spain) is about 300 Mio. € with a reachable potential for E+H of about 500k €.
- With an announced supply of 6000-7000 MW until 2012, it would account for a potential of 50-70 Mio. € for the E+H Group world wide

EPC‘s and Technology Owner

Solar Millennium, Lahmeyer International, Fichtner, MAN Ferrostaal, Kraftanlagen München, m+w zander, eSolar, Flagsol, Schott glass made of ideas, Flabeg, Solel, FPL Group, Lauren, International Automated Systems, PSE projects in solar energy, Solar Power Group, Novatec BioSol, SkyFuel

Investoren

ACS, cobra, Sener, Abener Energía, S.A., Abengoa, acciona Energía, Iberdrola Renovables

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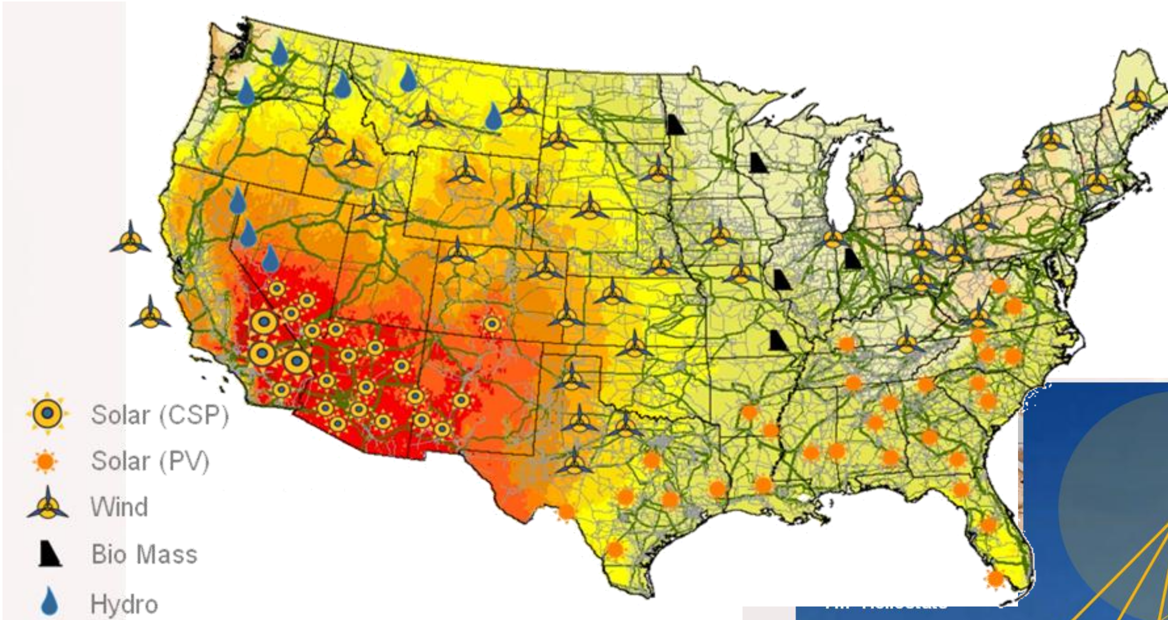
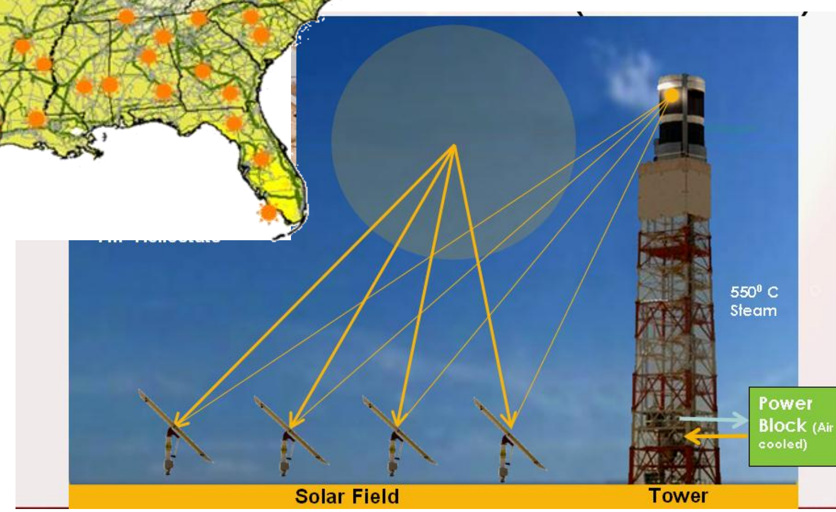
Big business is waiting for you





May 2009 Bright Source signed a contract with Californian company Pacific Gas & Electric to build solar tower power plants with a total capacity of 1310 MW

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CSP Projects South-Western USA

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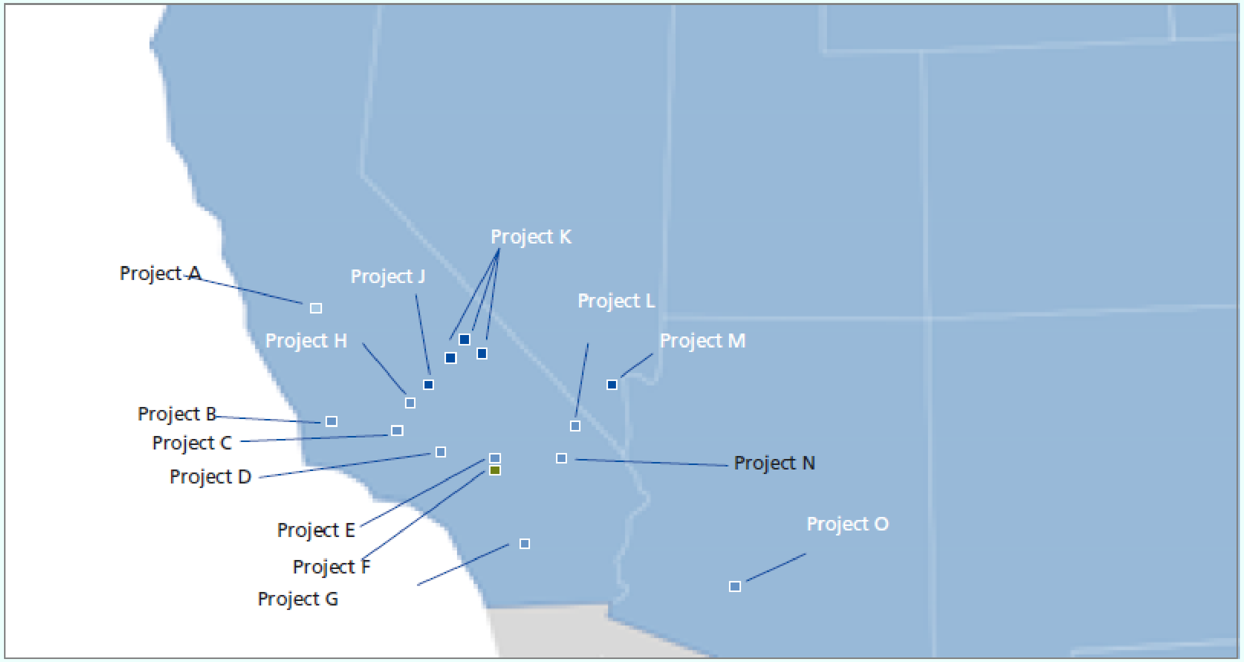
South-Western USA: Location of CSP Projects

Source: EuPD Research 2008



Stage 1
Stage 2
Stage 3
Stage 4
Stage 5

EuPD Research 74

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Projekt Desertec-Eumena

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21. SEPTEMBER 2010

ZUVERSICHT ÜBER DIE FINANZIERUNG VON MAROKKOS CSP PROJEKTEN

Marokko strebt bis 2020 den Bau von 5 solarthermischen Kraftwerken an. Die Leistung der Kraftwerke soll insgesamt 2.000 MW betragen. Zusammen mit der Weltbank will der Clean Technology Fund eine Garantie über 750 Millionen US-Dollar bereitstellen. Marokkos Ziel ist es bis 2020 eine nationale Solaragentur zu gründen und 42 Prozent seines Energiebedarfes mit erneuerbaren Energien zu decken.

- ENGLISCHEN ARTIKEL LESEN UNTER WWW.ECOSEED.ORG

16. SEPTEMBER 2010

RUND 6 MILLIARDEN US-DOLLAR FÜR CSP IN KALIFORNIEN

Die kalifornische Energiebehörde genehmigt den Bau und Betrieb von solarthermischen Kraftwerken mit einer Gesamtleistung von rund 1.000 Megawatt (MW). Mit dem Bau will Solar Millennium noch 2010 beginnen. Während der Bauphase werden rund 2.500 Jobs geschaffen. Der Dampfkreislauf der Turbinen wird nicht mit Wasser, sondern mit Luft gekühlt. Arnold Schwarzenegger, Gouverneur von Kalifornien, sieht in Solarenergie und anderen erneuerbaren Energien die Zukunft von Kaliforniens Wirtschaft. Mit Solarkraftwerken in der kalifornischen Wüste können Los Angeles und andere Metropolen an der amerikanischen Westküste mit umweltfreundlichem Strom versorgt werden.

- ARTIKEL LESEN UNTER WWW.FINANZNACHRICHTEN.DE

14. SEPTEMBER 2010

DIE WELTBANK STELLT 5,6 MILLIARDEN US$ FÜR CSP ANLAGEN IN NORDAFRIKA BEREIT

Das "Clean Technology Fund Trust Fund Committee" (CTF TFC) genehmigte die Investitionsplanung für das CSP Kraftwerk in der MENA-Region. Die Investitionssumme von 5,6 Milliarden US$ soll den Bau von CSP Anlagen mit einer Kapazität von insgesamt 1 GW beschleunigen.

- READ ARTICLE ON WWW.BIKYAMASR.COM

03. SEPTEMBER 2010

ABENER UND TEYMA BAUEN CSP ANLAGE IN DEN VEREINIGTEN ARABISCHEN EMIRATEN

Shams 1, eine 100 MW CSP Anlage in Abu Dhabi, soll sich über eine Fläche von 300 Hektar erstrecken. Die Gesellschafter von Anlage Shams 1 sind Masdar (60%), Total (20%) und Abengoa Solar (20%).

- ENGLISCHEN ARTIKEL LESEN AUF WWW.RENEWABLEENERGYFOCUS.COM

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Solar map

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How old is the idea to use solar energy?

In the year 212 BC, **Archimedes of Syracuse** used polished screens of bronze to concentrate the sun rays trying to burn the wood of the ships from the powerful roman empire, which was besieging Syracuse.

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2. Technology

Technology

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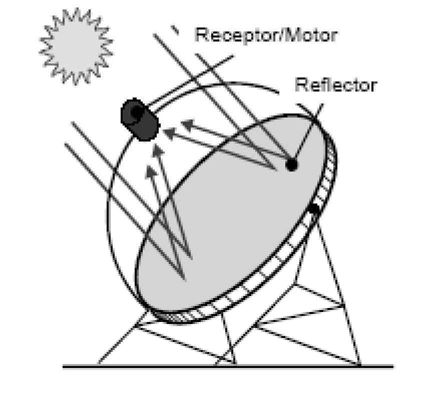
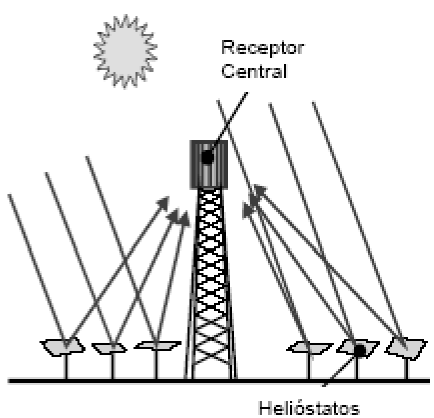
Currently available technology



Discos parabólicos

Parabolic dishes Stirling:

They are small independent units usually parabolic reflector connected to a Stirling engine located at the focus. The concentration levels are from 1,000 to 4,000 and the unit powers are 5 to 25 kW.



Receptor Central

Systems tower or central receiver:

They consist of a field of heliostats follow the sun's position at all times (elevation and azimuth) and direct the reflected beam to the focus placed on top of a tower. The orders of concentration are from 200 to 1,000 and the unit powers from 10 to 200 MW.

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Technology

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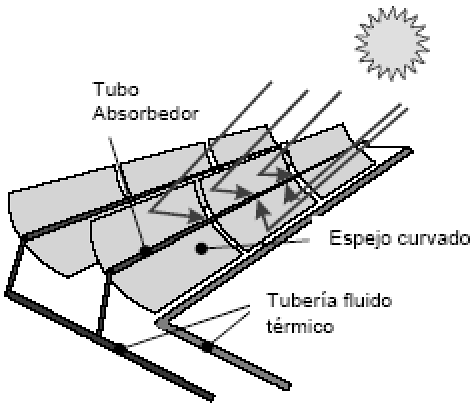
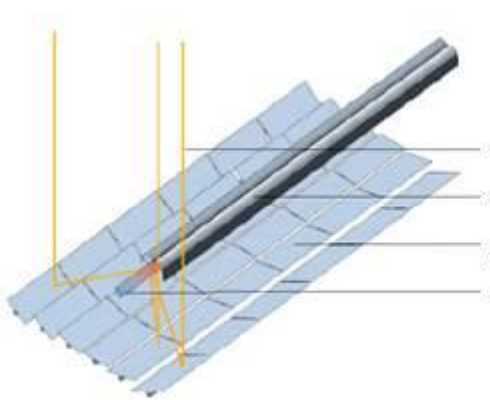
Currently available technology



Cilindro-parabólicos

Parabolic trough concentrators mirrors:

Linear focus concentrators are tracked in one axis, the radiation levels of 30 to 80 times per field and power unit from 30 to 80 MW.



Fresnel

Fresnel:

The sun's rays impinging on the mirrors are reflected to a central manifold through which circulates a heat transfer oil.

It is a technology that combines the parabolic trough and central tower.

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Central Tower

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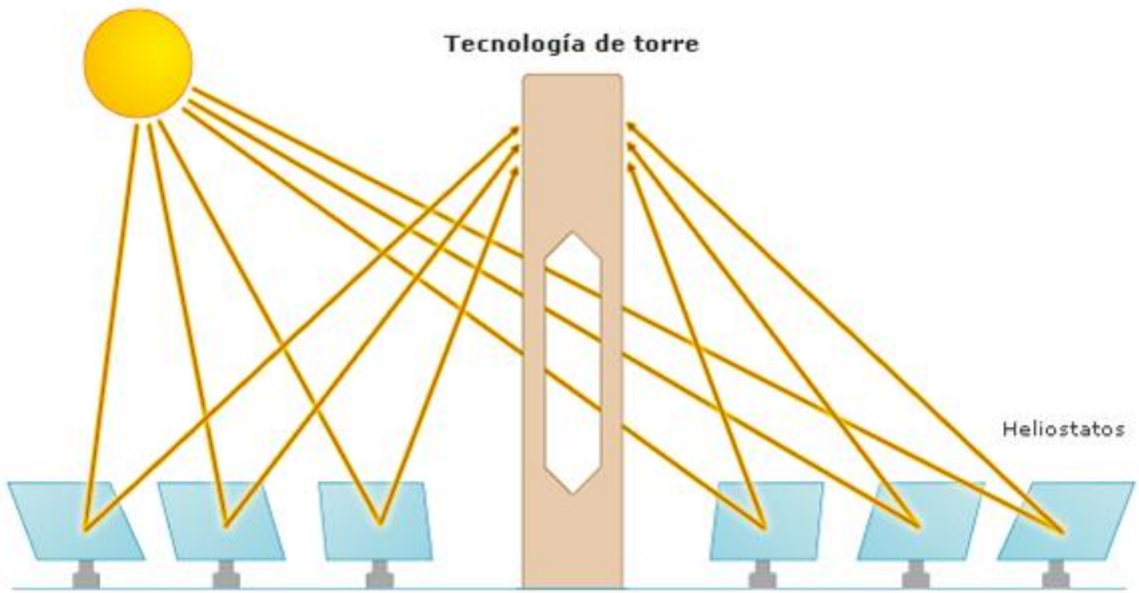
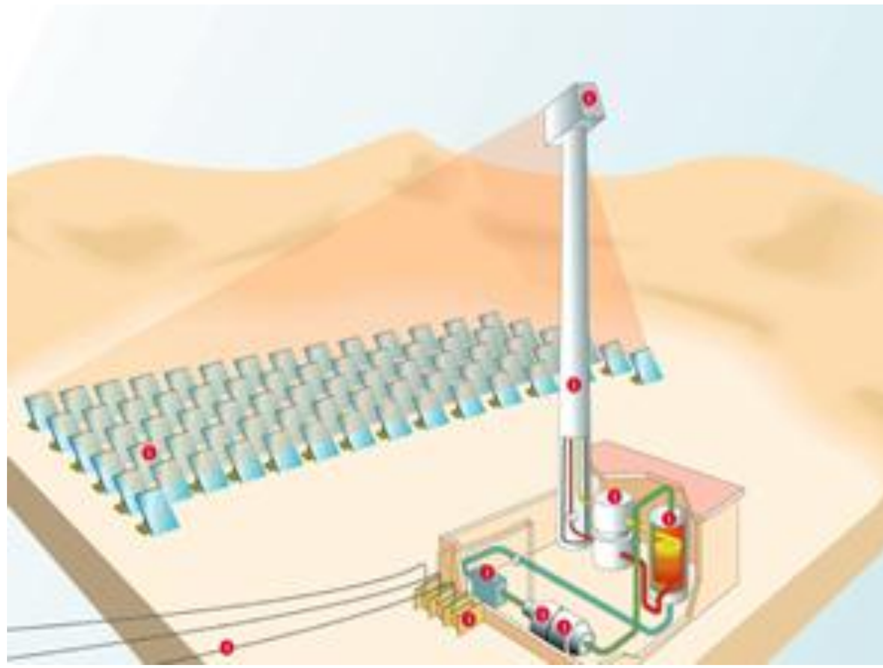
Operation principle



An **heliostat field** or mobile mirrors oriented regard the sun position in the sky, reflecting the sun rays to concentrate it 600 times over a receptor located at the top of a central tower of the field. The so generated heat is transmitted to a fluid to produce steam which is used in a turbine for the production of electricity.

Central Tower

Operation principle



The **receptor**, transmit the received heat to a work fluid (water, smelting salt, air). This fluid transmit the heat to produce a high temperature steam for the production of electricity.

Fresnel

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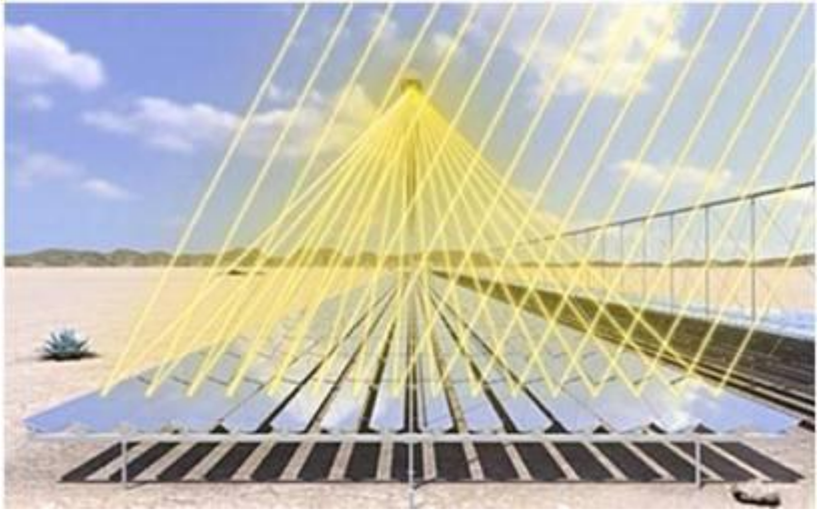
Operation principle

- Highlight is the construction simplicity and the low costs.
- The reflection mirror are flat, which simulate a curve one using the individual variable reflection angle (related with absorber).
- The reflection mirrors are constructed with normal glasses.
- The parabolic mirrors increase the efficiency more than 15% compared to the Fresnel ones, but considering the spare in construction costs and design it is possible to compensate the additional price of the investment.



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Fresnel

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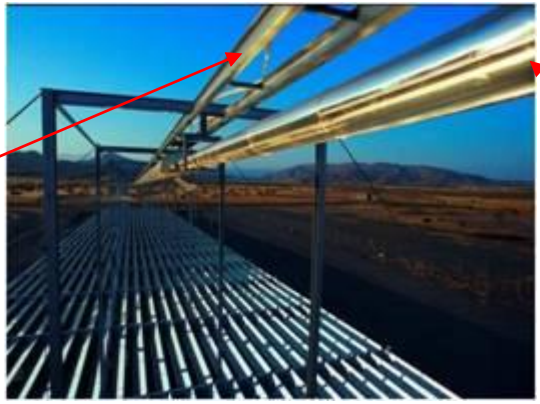
Operation principle

Due to the little size of the Fresnel mirrors, they are less sensible to the effect of the wind.

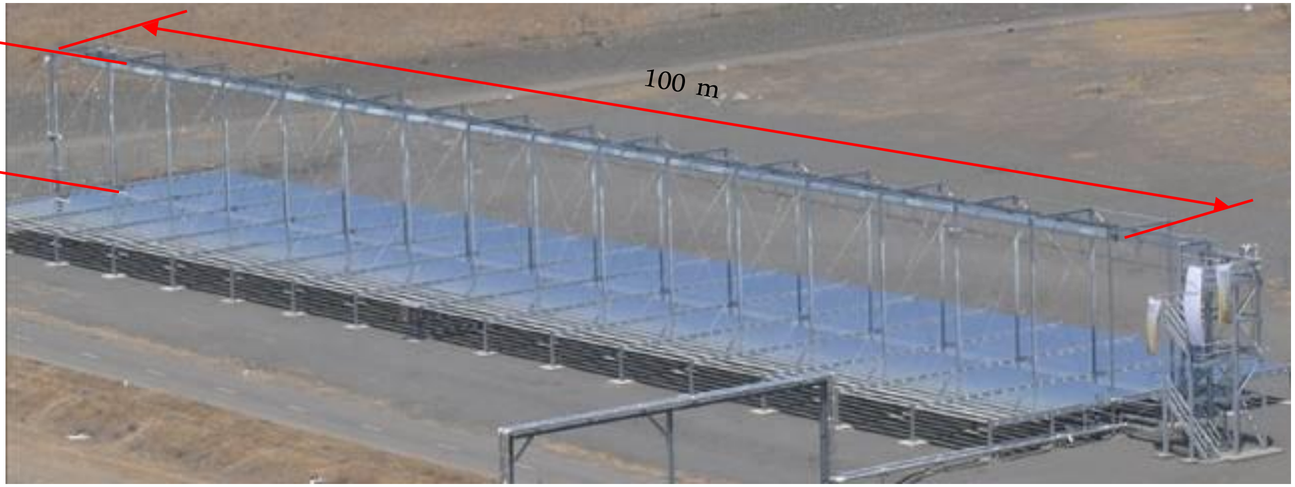
Secondary Mirror



steam:

450°C

100 bar



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Solar thermal power plant

3.1.1 Section of a plant

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Thermo Solar Power Process map

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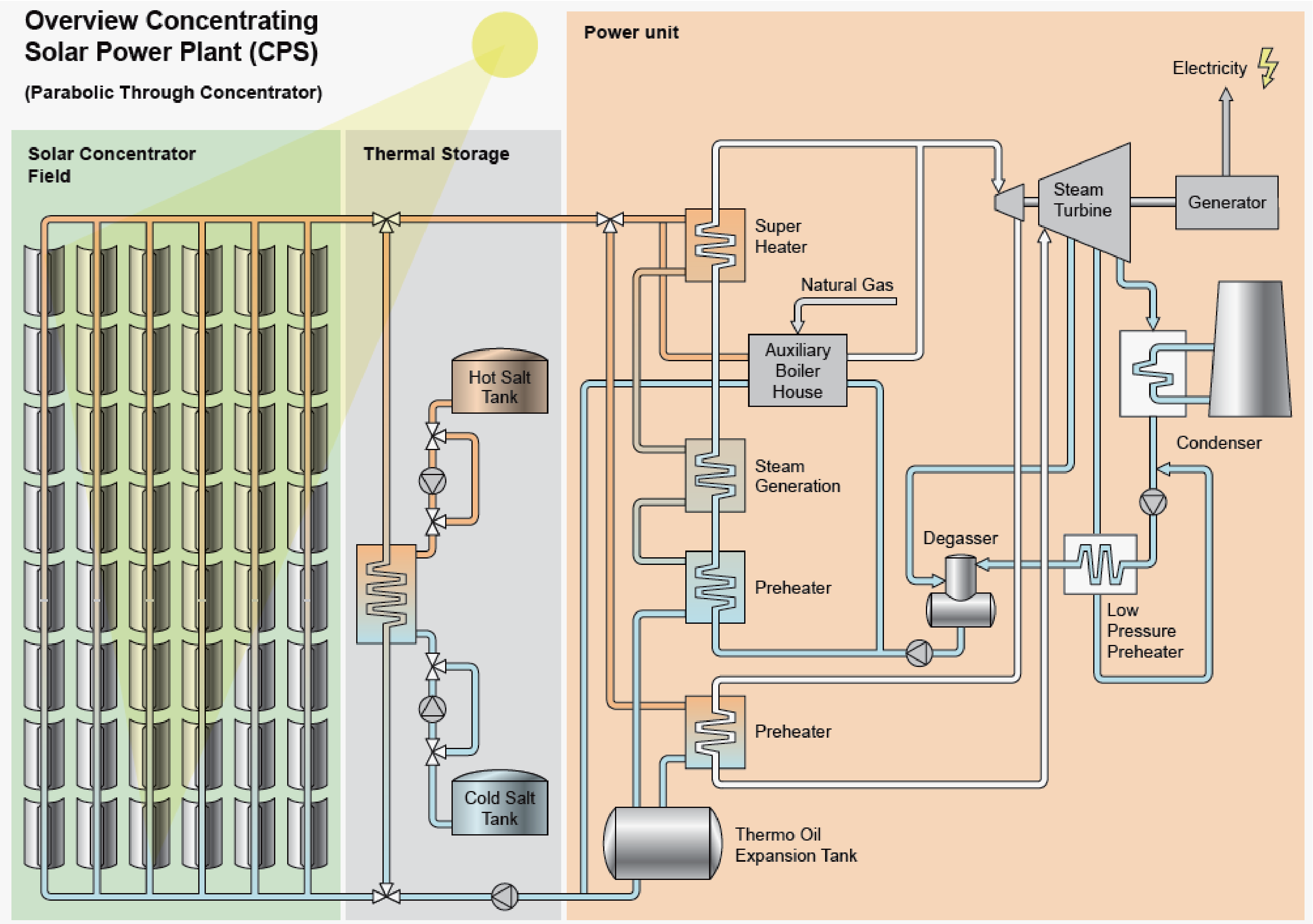

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Parabolic trough mirror plant

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- Aerial photograph of a 50MW plant

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Section of a plant – parabolic trough mirror

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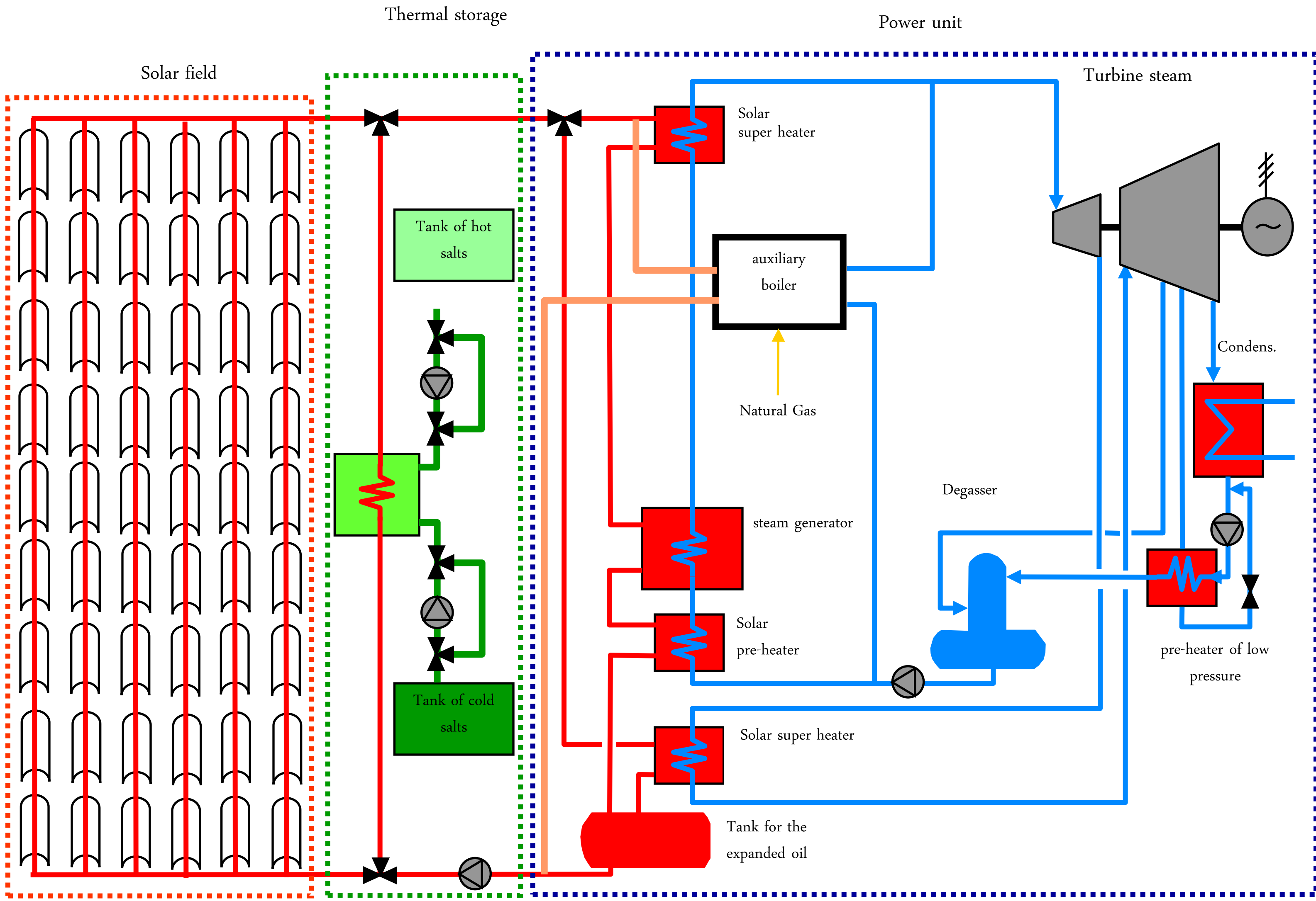
Basic scheme of a plant



Section of a plant – Central tower

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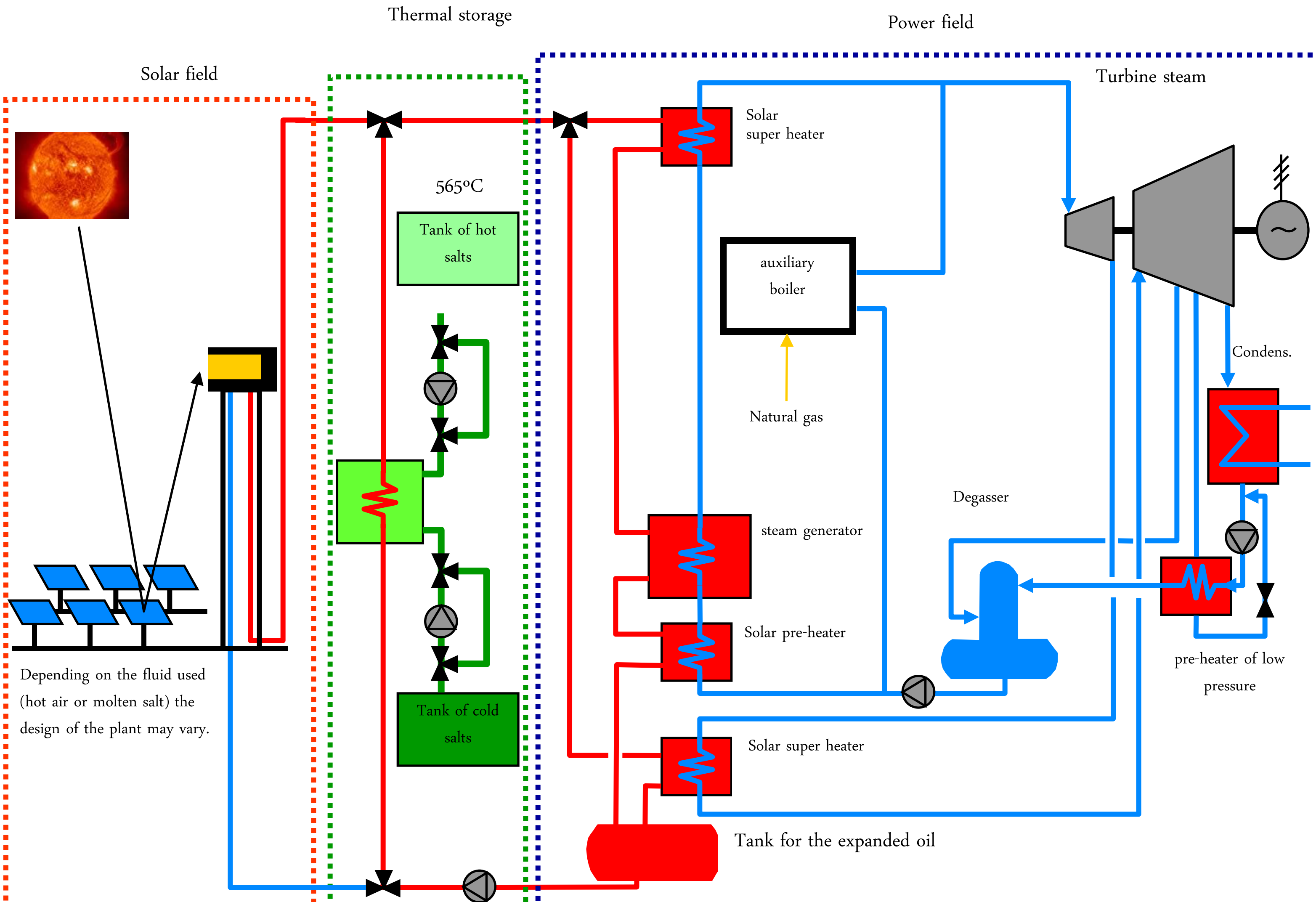
Basic scheme of a plant (deposit of salts + boiler)



Solar thermal power plant

3.1.2. Solar field

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Solar field instrumentation

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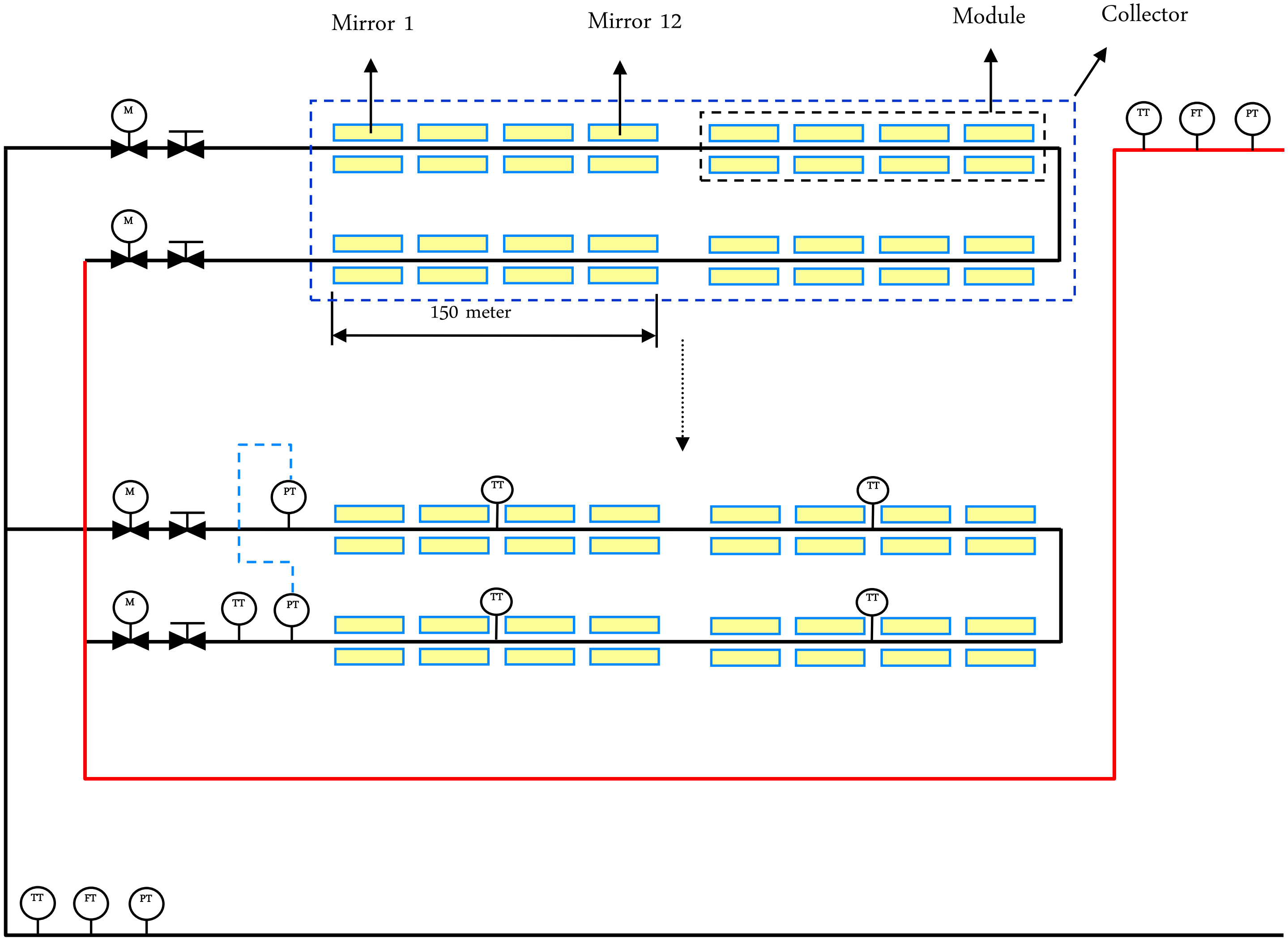
Collector parabolic trough mirror (50MWt)



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Solar field instrumentation

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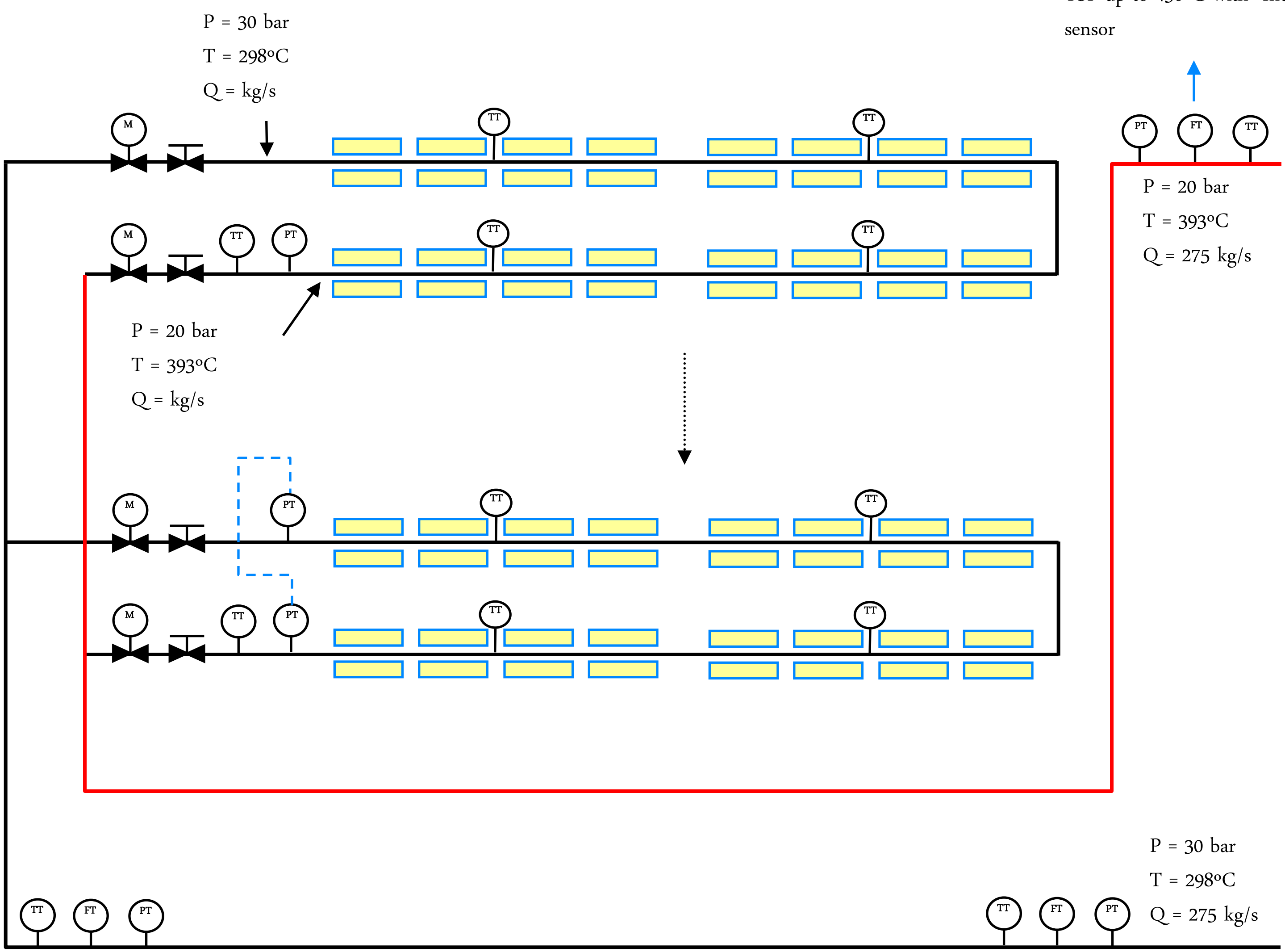
Collector parabolic trough mirror (50MWt)

72F3H-S*1A********

TSP up to 450°C with Inconel sensor



Solar field instrumentation - temperature

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Temperature sensors in the tube absorbing

There are two ways to install sensors that measure the temperature in the absorber tube

A) Temperature sensor to the outside.

B) Temperature sensor between the mirror and the collector tube

Keep in mind that the temperature in the absorber tube/collector is 400ºC and at a distance of 100 mm tube, the temperature is still approximately 200ºC.

Depending on the type of installation the following problems show up:

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Temperature sensors in the tube absorbing

A) Temperature sensor to the outside.

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Solar field instrumentation - temperature

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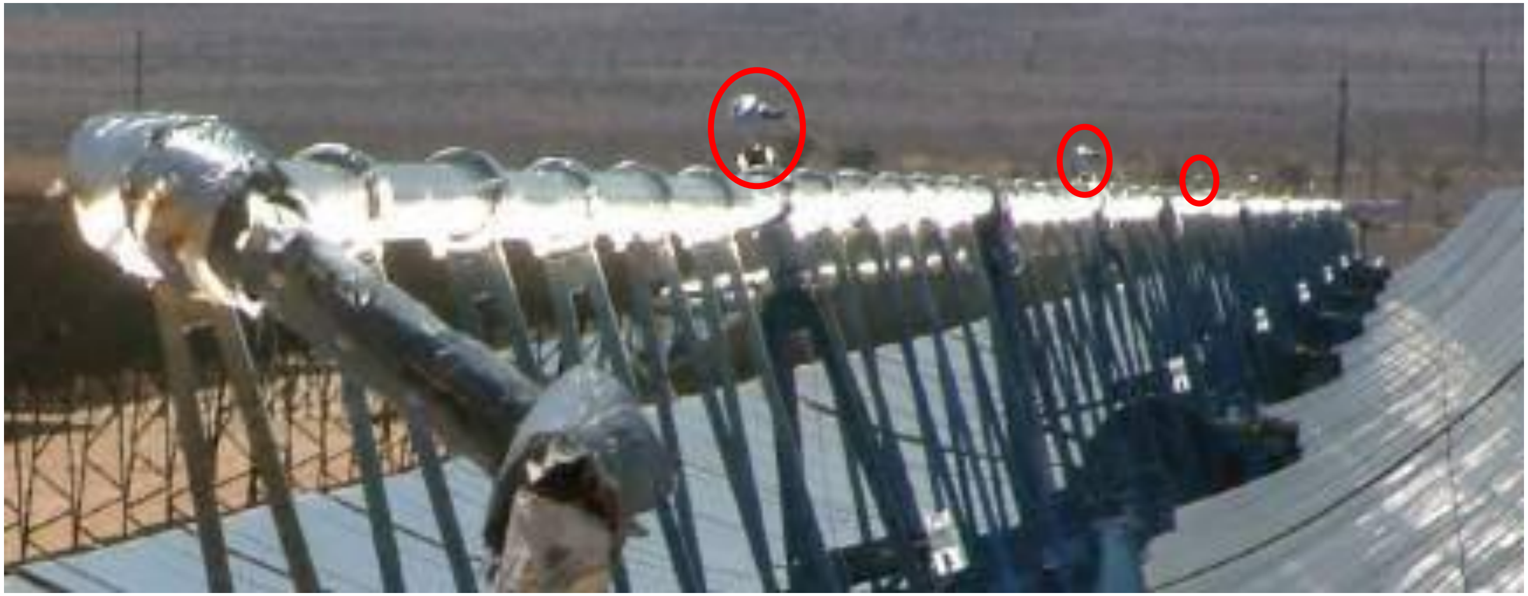
Temperature sensors in the tube absorbing

A) Temperature sensor to the outside.



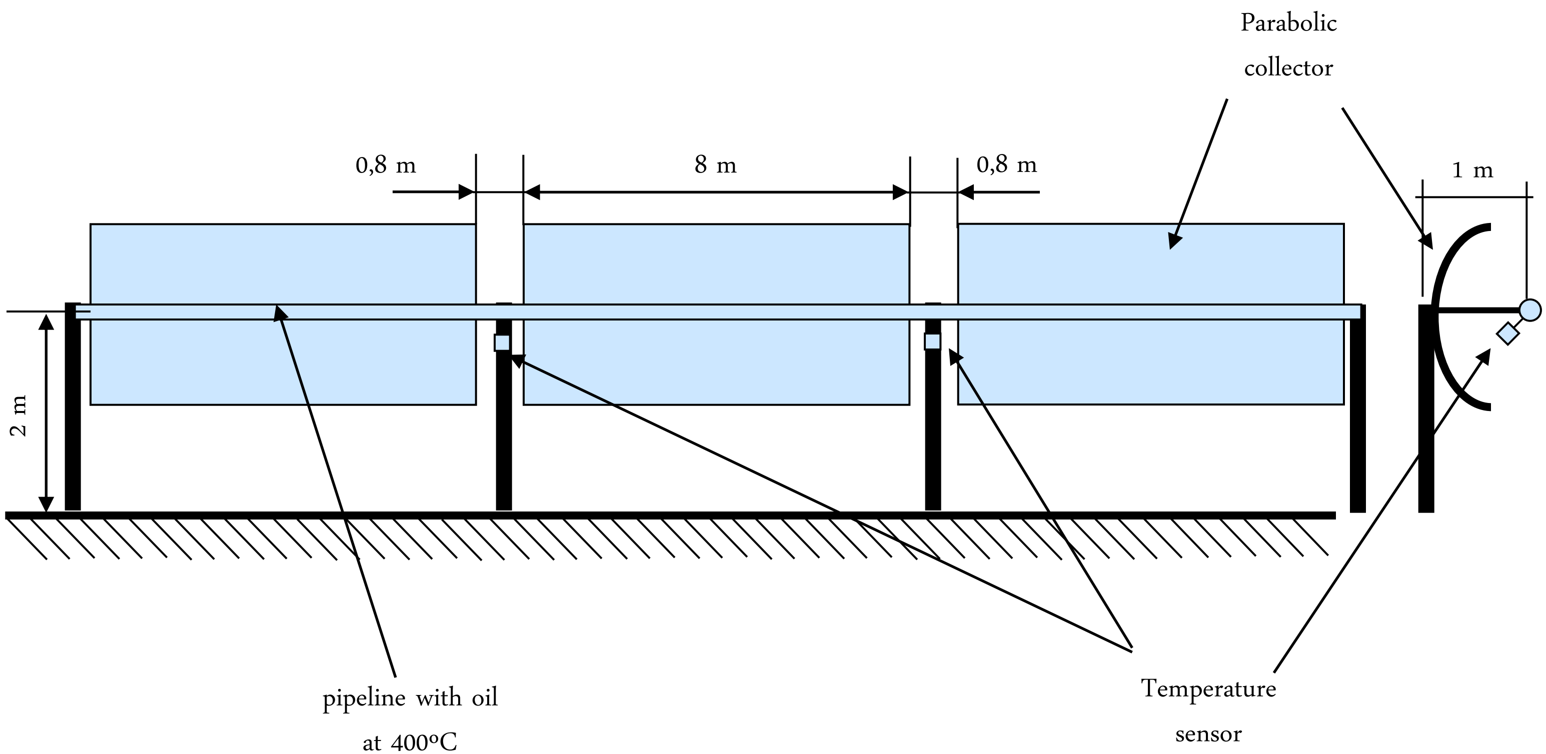
The electrical connection must pass close to the collector tube and plastic parts may suffer from this excess of temperature.

Solar field instrumentation - temperature

B) Temperature sensor between collector and collector pipeline.

Typical installation

Dimensioning



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Solar field instrumentation - temperature

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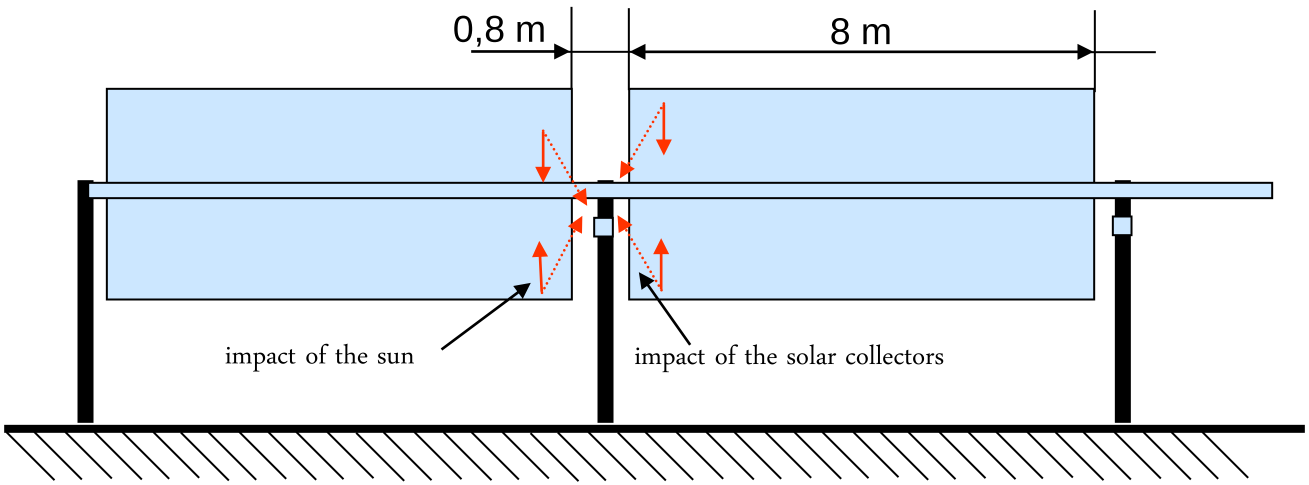
Temperature sensors in the collector pipeline

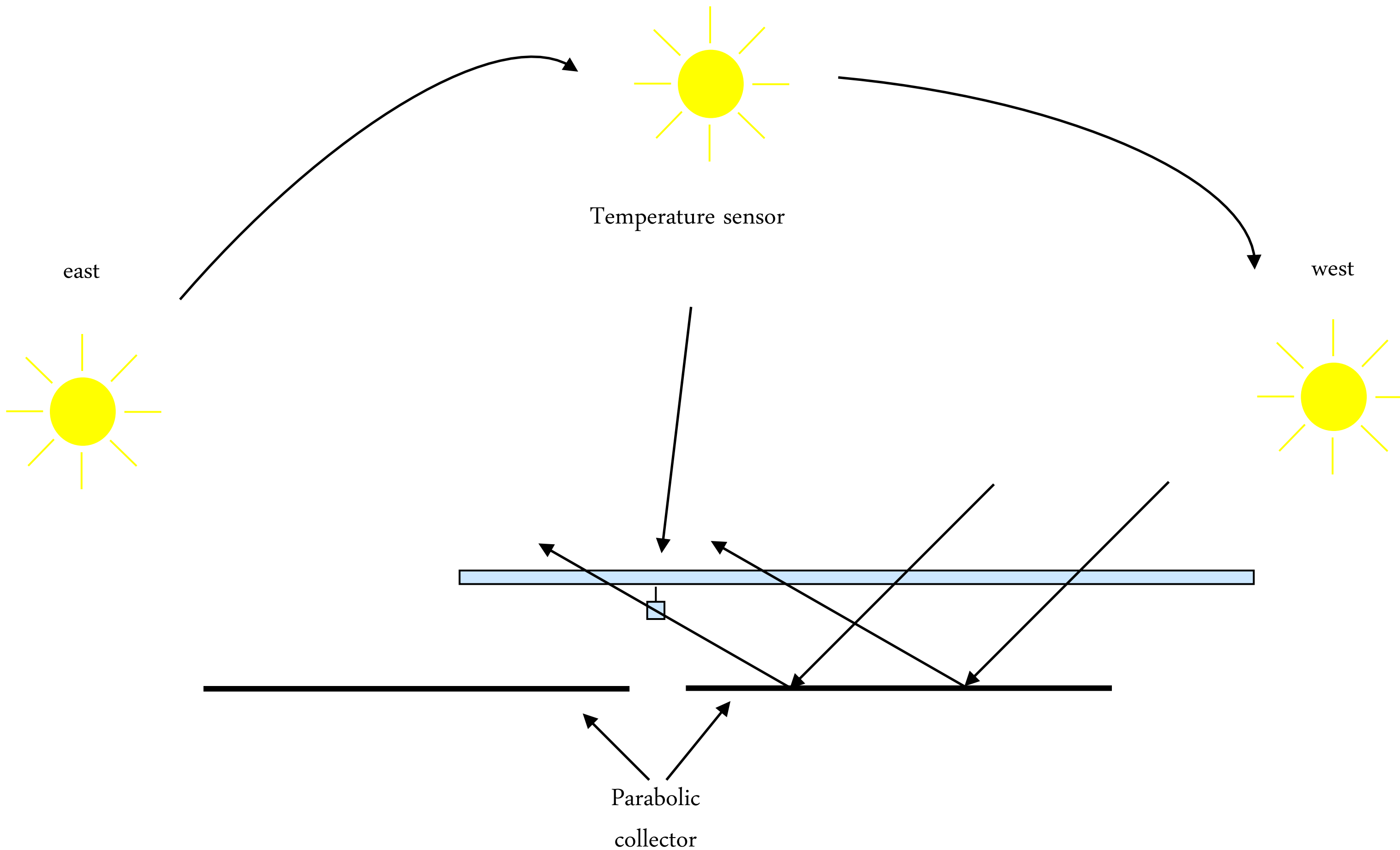
In such installations the following problem exists:

- In addition to the temperature radiation from the process the lateral temperature impact caused by:
  - Imperfect solar collector and
  - Changing sun beam angles by seasons



Solar field instrumentation - temperature

B) temperature sensor between collector and collector pipeline



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Solar field instrumentation - temperature

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Temperature sensors in the collector pipeline

B) temperature sensor between collector and collector pipeline

Recommendation: TST310 / TSC310 with the following installation:

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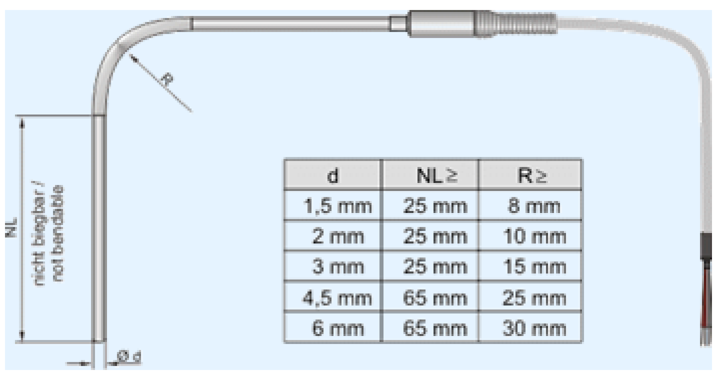
Solar Collector Plant

Temperature: Our special solution

TSC310 or TST310 + TA50 + TA570



d	NL ≥	R ≥
1,5 mm	25 mm	8 mm
2 mm	25 mm	10 mm
3 mm	25 mm	15 mm
4,5 mm	65 mm	25 mm
6 mm	65 mm	30 mm

Solar field instrumentation

Characteristics of Therminol VP1

Fluid: thermal Oil (HTF)

Temperature: 300 - 400°C

Flow: min. 1.200 kg/s (5.500 m3/h)

DN sizes: 18”- 34”

PN process: 30 bar

Solar thermal power plant

Temperature °C	Density kg/m³	Thermal Conductivity W/m.K	Heat Capacity kJ/kg.K	Viscosity Dynamic mPa.s	Viscosity Kinematic mm²/s**	Vapour pressure (absolute) kPa*	Enthalpy kJ/kg	Latent Heat vap. kJ/kg
12	1071	0.137	1.523	5.48	5.12	-	18.1	419.0
20	1064	0.136	1.546	4.29	4.03	-	30.4	414.7
30	1056	0.135	1.575	3.28	3.10	-	46.0	409.3
40	1048	0.134	1.604	2.60	2.48	-	61.9	403.9
50	1040	0.133	1.633	2.12	2.03	-	78.1	398.6
60	1032	0.132	1.662	1.761	1.707	-	94.5	393.3
70	1024	0.131	1.690	1.492	1.458	-	111.3	388.1
80	1015	0.130	1.719	1.284	1.265	-	128.4	382.9
90	1007	0.129	1.747	1.119	1.111	-	145.7	377.8
100	999	0.128	1.775	0.985	0.986	0.5	163.3	372.7
110	991	0.126	1.803	0.875	0.884	0.8	181.2	367.6
120	982	0.125	1.831	0.784	0.798	1	199.4	362.6
130	974	0.124	1.858	0.707	0.726	2	217.8	357.5
140	965	0.123	1.886	0.642	0.665	3	236.5	352.6
150	957	0.121	1.913	0.585	0.612	5	255.5	347.6
160	948	0.120	1.940	0.537	0.566	7	274.8	342.7
170	940	0.118	1.968	0.494	0.526	9	294.3	337.7
180	931	0.117	1.995	0.457	0.491	13	314.1	332.8
190	922	0.115	2.021	0.424	0.460	18	334.2	327.9
200	913	0.114	2.048	0.395	0.432	24	354.6	323.0
210	904	0.112	2.075	0.368	0.407	32	375.2	318.0
220	895	0.111	2.101	0.345	0.385	42	396.1	313.0
230	886	0.109	2.128	0.324	0.366	54	417.2	308.0
240	877	0.107	2.154	0.305	0.348	68	438.6	303.0
250	867	0.106	2.181	0.288	0.332	86	460.3	297.9
260	857	0.104	2.207	0.272	0.317	108	482.2	292.7
270	848	0.102	2.234	0.258	0.304	133	504.4	287.5
280	838	0.100	2.260	0.244	0.292	163	526.9	282.2
290	828	0.098	2.287	0.232	0.281	198	549.7	276.8
300	817	0.096	2.314	0.221	0.271	239	572.7	271.2
310	806	0.095	2.341	0.211	0.262	286	595.9	265.6
320	796	0.093	2.369	0.202	0.254	340	619.5	259.7
330	784	0.091	2.397	0.193	0.246	401	643.3	253.8
340	773	0.089	2.425	0.185	0.239	470	667.4	247.6
350	761	0.086	2.454	0.177	0.233	548	691.8	241.3
360	749	0.084	2.485	0.170	0.227	635	716.5	234.7
370	736	0.082	2.517	0.164	0.222	732	741.5	227.8
380	723	0.080	2.551	0.158	0.218	840	766.9	220.7
390	709	0.078	2.588	0.152	0.214	959	792.5	213.2
400	694	0.076	2.628	0.146	0.211	1090	818.6	205.3
410	679	0.073	2.674	0.141	0.208	1230	845.1	197.0
420	662	0.071	2.729	0.137	0.206	1390	872.1	188.0
425	654	0.070	2.760	0.134	0.205	1470	885.8	183.3

* 1 bar = 100 kPa - ** 1 mm²/s = 1 cSt

Note: Therminol is a registered trademark of Solutia

Solar field instrumentation

Additional instrumentation

- Pressure sensors are used to monitor possible fluid losses within the circuit.

- Temperature sensors at the beginning and at the end of the pipeline are used to verify that collectors are working in a correct way and that temperature is correct.

- At the entrance and the exit of the field, temperature, pressure and flow is monitored

Biogas Competence

Biogas energy measurement

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Solar PV energy

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3.1.3. thermal storage system

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Thermal Storage System

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Aerial photograph

Thermal storage system

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Temperature measurement

Medium: liquid salt (60% KNO_3 + 40% $NaNO_3$)

Process temperature:

cold vessel: 290°C

hot vessel: 390°C – 565°C

Process pressure: 1 bar

Thermal storage system

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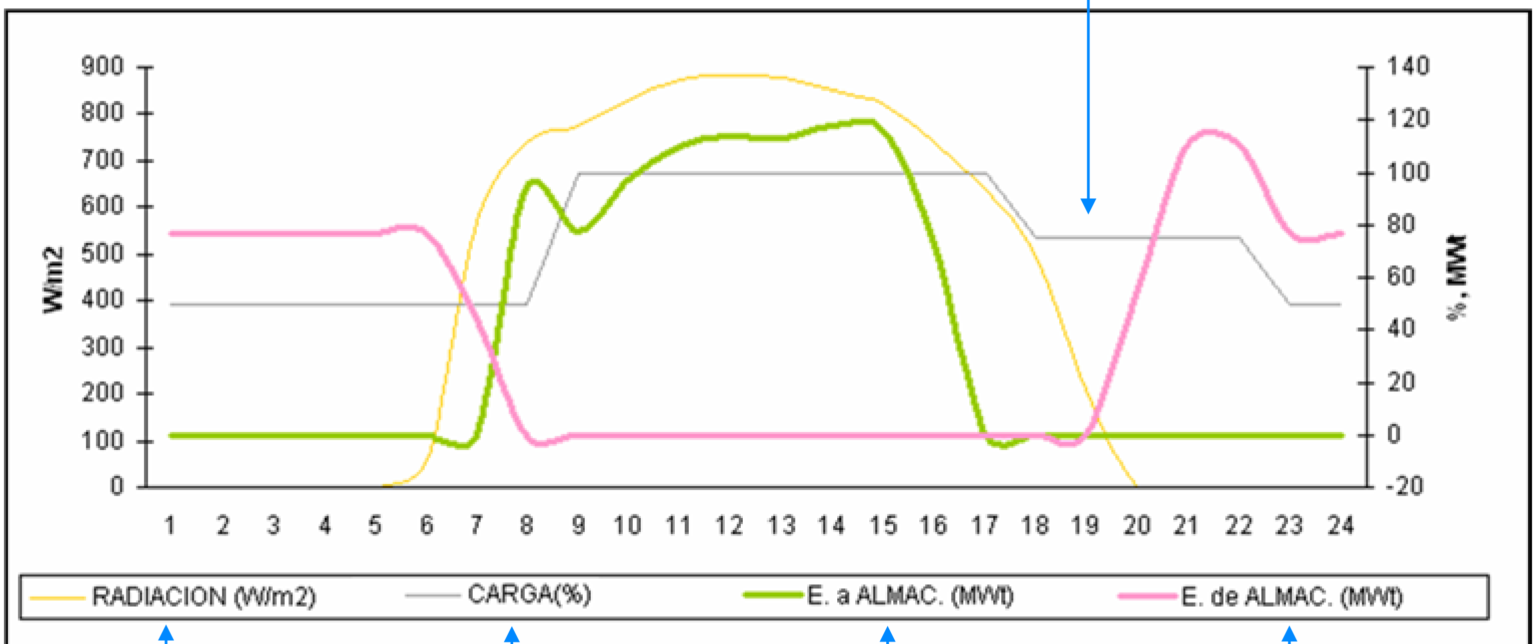
W@M – Life Cycle Management

Load cycle / unload cycle of thermal storage system (50 MW)

load level during a day (depending of sun radiation)



Incidental sun radiation

load of vessel

stored energy during sunshine

stored energy which is used whenever there's no sunshine

Thermal storage system

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Material thermal storage system

Medio de almacenamiento	Temp. (ºC) Fría	Temp. (ºC) Cal	Densidad media (kg/m^3)	Cond. térmica media (W/m-K)	Capacidad calorífica media (kJ/kg-K)	Capacidad calorífica por unidad de volumen (kWht/m^3)	Costes medios por kg ($/kg)	Costes medios por kWht ($/kWht)
Medio líquido								
Aceite mineral	200	300	770	0.12	2.6	55	0.3	4.2
Aceite sintético	250	350	900	0.11	2.3	57	3	43
Aceite de silicona	300	400	900	0.1	2.1	52	5	80
Sales de nitrito	250	450	1825	0.57	1.5	152	1	12
Sales de nitrato	265	565	1870	0.52	1.6	250	0.7	5.2
Sales de carbonato	450	850	2100	2	1.8	430	2.4	11
Sodio líquido	270	530	850	71	1.3	80	2	21

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Foto 3. Andasol-1. Sistema de almacenamiento

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Molten salt thermo storage

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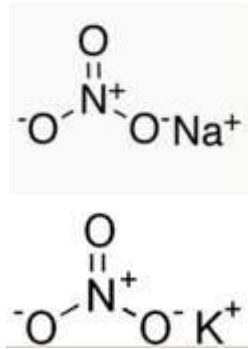

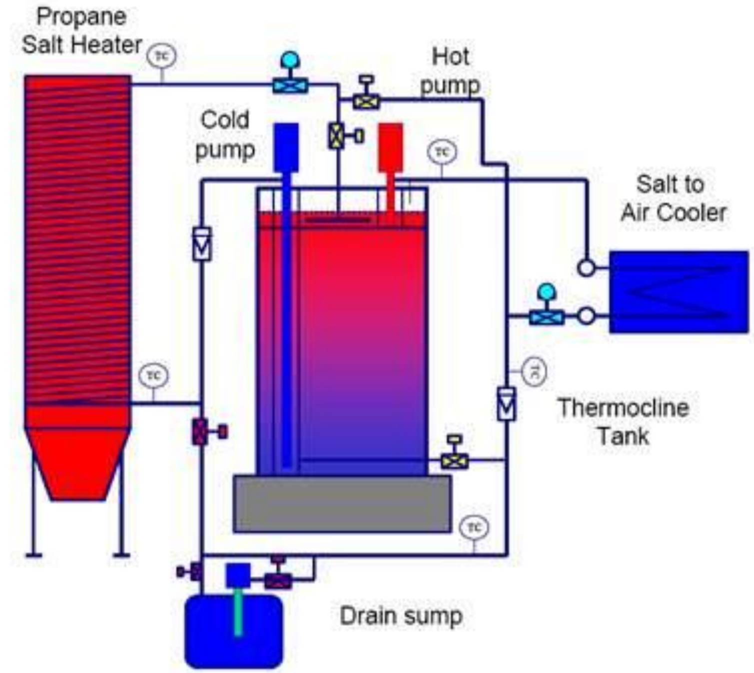

The molten salt is a mixture of 60 % sodium nitrate and 40 % potassium nitrate, also called Saltpetre. It is non-flammable and non-toxic, and has already been used in the chemical and metals industries as a heat-transport fluid, so experience with such systems exists in non-solar applications. The salt melts at 221 °C (430 °F). It is kept liquid ~290 °C in an insulated "cold" storage tank. The liquid salt is pumped through heat exchanger and will be heated up to 400°C. The liquid salt could be heated up 566 °C, but the limitation is the thermo oil is used in the collector tubes.

Thermal storage system

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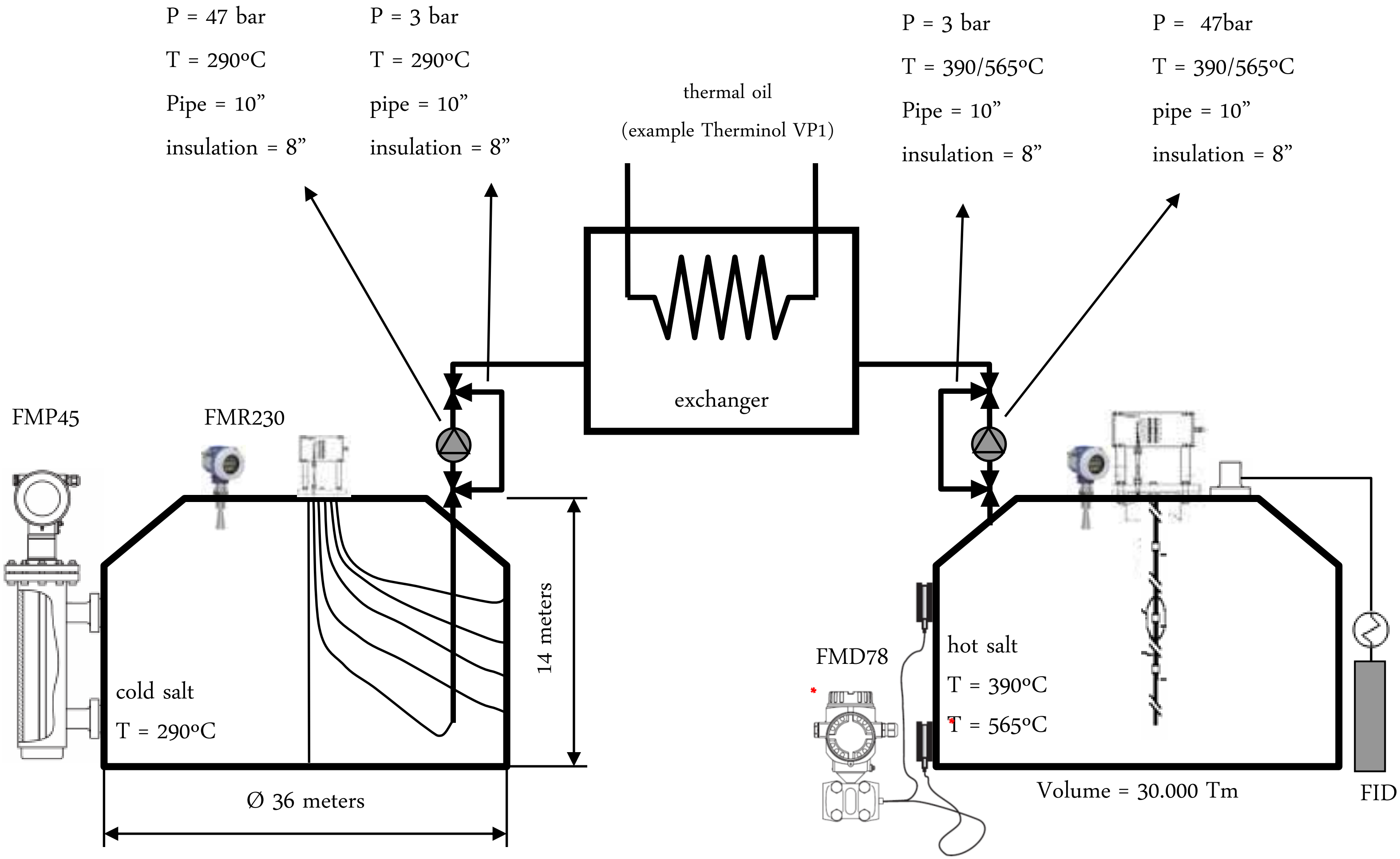

Composition of salt:

60% NO_3K

40% NO_3Na

Note 1: The dimension of the storage tanks are for a plant of 50 MW but can vary. Storage tanks for 8h of autonomy are not yet found. However tanks with Ø 30 x 17 m (Andasol III) and Ø 40 x 10 m exist already....

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Thermal storage system

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Level measurement

A differentiation has to be made between a cold salt and hot salt tank

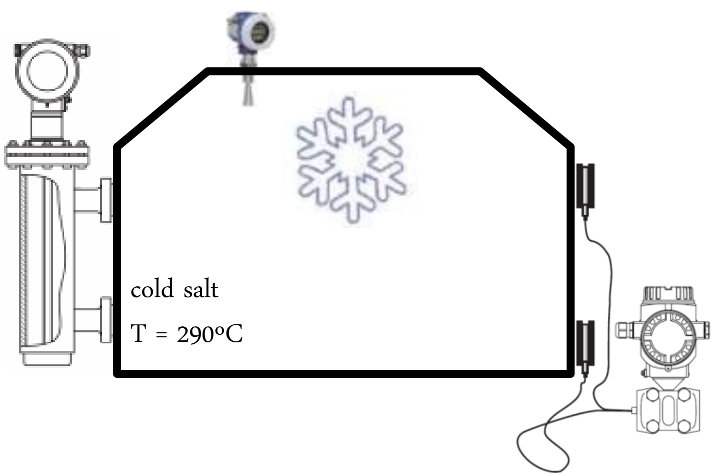
A) cold salt tank: temperature = 290°C

Basically, the following principles may be used:

A.1) Radar non-contact

A.2) Guided Radar

A.3) Differential pressure

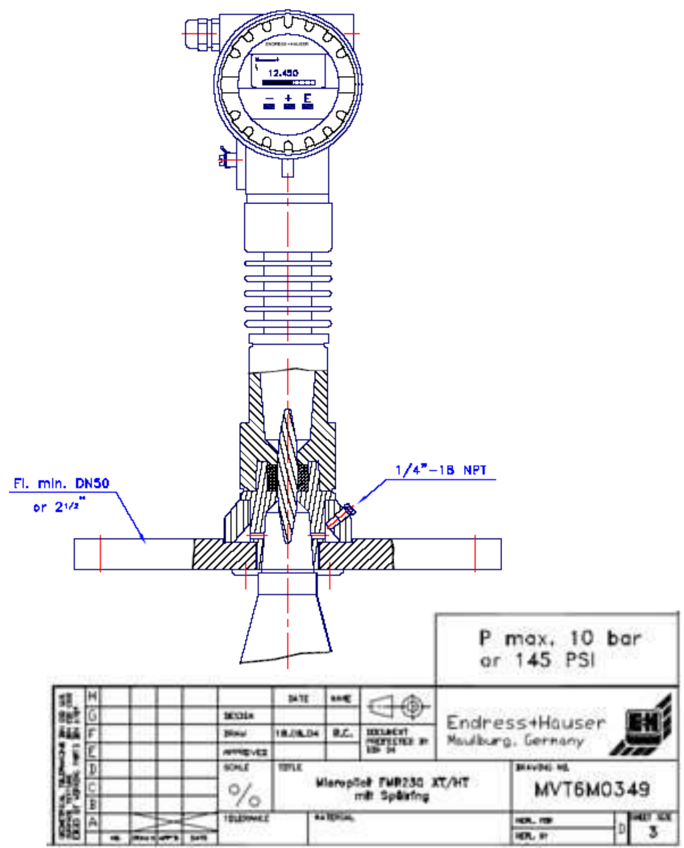


Thermal storage system

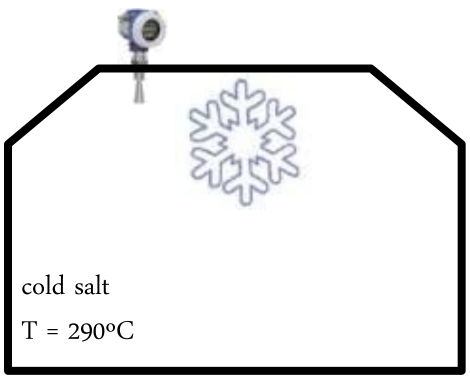
Level measurement in cold salt tank (290°C)

A.1) Radar non-contact

For these temperatures, graphite seals are to be used:



FMR230



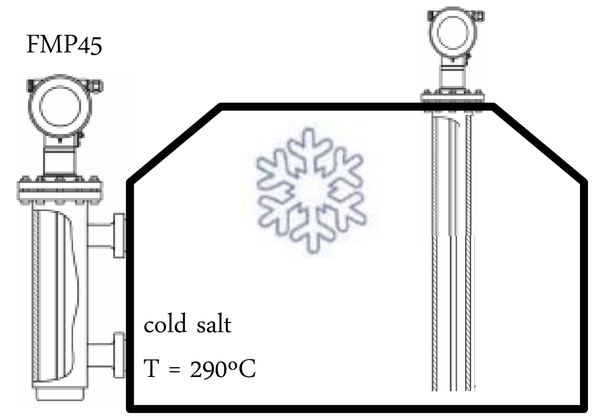
Thermal storage system

Level measurement in cold salt vessel (290°C)

A.2) Guided Radar

2 solutions are possible:

- bypass pipeline
- *direct into the vessel*



Bypass pipeline: in order to avoid any intrusive system put into the vessel, the guided radar is installed in a bypass pipeline. A thermcal tracing has to be installed in order to keep salt temperature above the freezing point (> 250°C).

Direct into the vessel: it is recommended to use a stilling well in order to avoid movements of the rod, stilling well to be fixed at the bottom of the vessel

Note:
Conditions of 400°C and 30 meters length require that all materials are made of stainless steel

Thermal storage system

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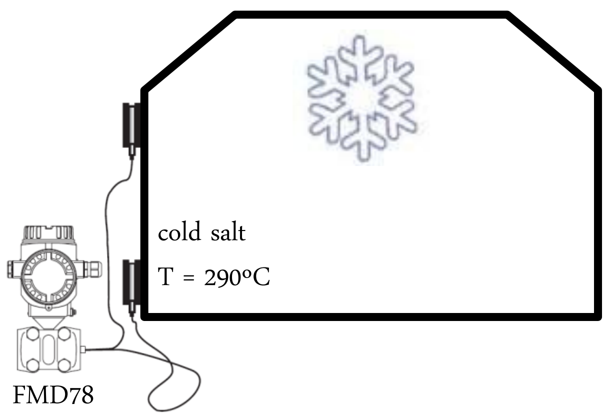
Level measurement in cold salt vessel (290°C)

A.3) Differential pressure

Flash mounted membranes are possible, as the thermal high temperature oil can support up to 400°C.

The length of capillaries can go up to 20 meters. However, please ask .....whenever the capillary length is bigger then 10m.

Mind density changes due to temperature variations.



Note: Gemasolar

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Level measurement

B) Hot salt vessel:

temperature with parabolic collector: 390°C

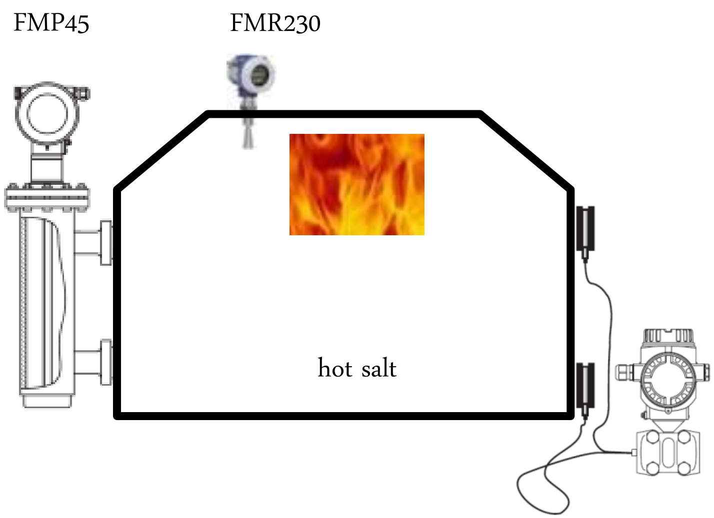
temperature in main tower: 565°C

Please refer to previously described alternatives:

B.1) Radar non-contact

B.2) Guided Radar

B.3) Differential pressure



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Level measurement hot salt vessel (390°C to 565°C)

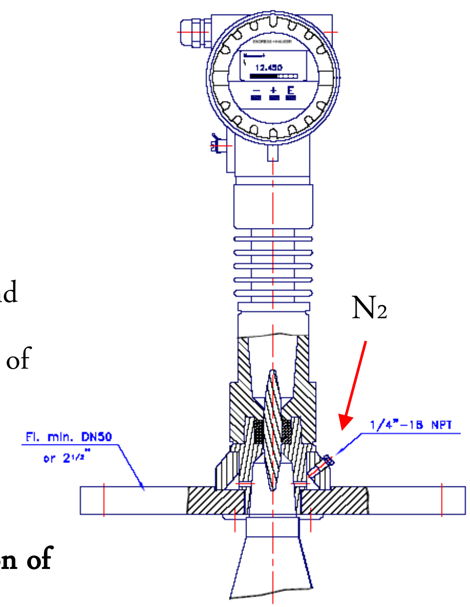
B.1) Radar non-contact:

B.1.1) Temp < 400°C: see cold salt vessel

B.1.1) Temp > 400°C: there are 2 options

Option 1:

it is required to cool the antenna by means of purging liquid nitrogen or air. Mind that too much cooling (below 250°C) can lead to crystal building (solid material) of the salt gases.



This solution is not recommended: **because of the problems of the flow calculation of the cooling.**

For these temperatures, graphite seals are to be used.

Thermal storage system

Level measurement hot salt vessel (390°C to 565°C)

B.1) Radar non-contact:

B.1.1) Temp < 400°C: see cold salt vessel

B.1.1) Temp > 400°C: there are 2 options

Option 2:

installation of radar gauge “externally”, which means that the antenna of the gauge is physically separated from the process by means of a (e.g.) plastic window. The microwaves pass this window for measurement

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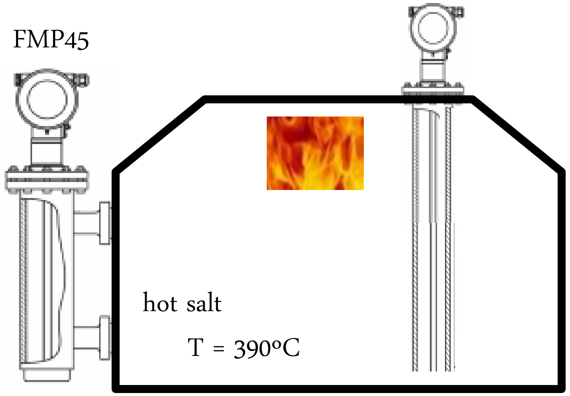
Level measurement hot salt vessel (390°C to 565°C)

B.2) Guided Radar

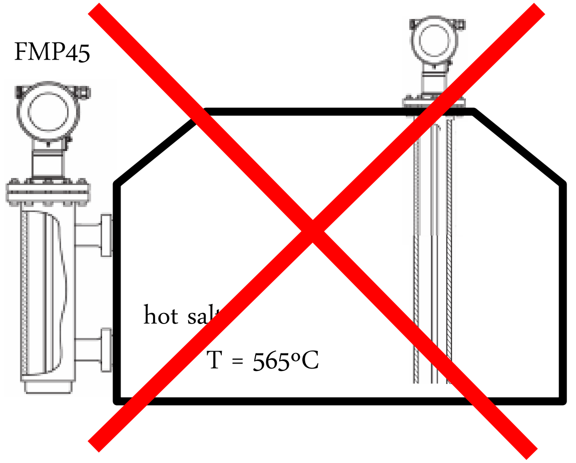
B.2.1) Temp < 400°C: (see cold salt vessel)

- bypass pipeline
- *directly into the vessel*



B.2.2) Temp > 400°C:

- there is NO solution by means of a guided radar



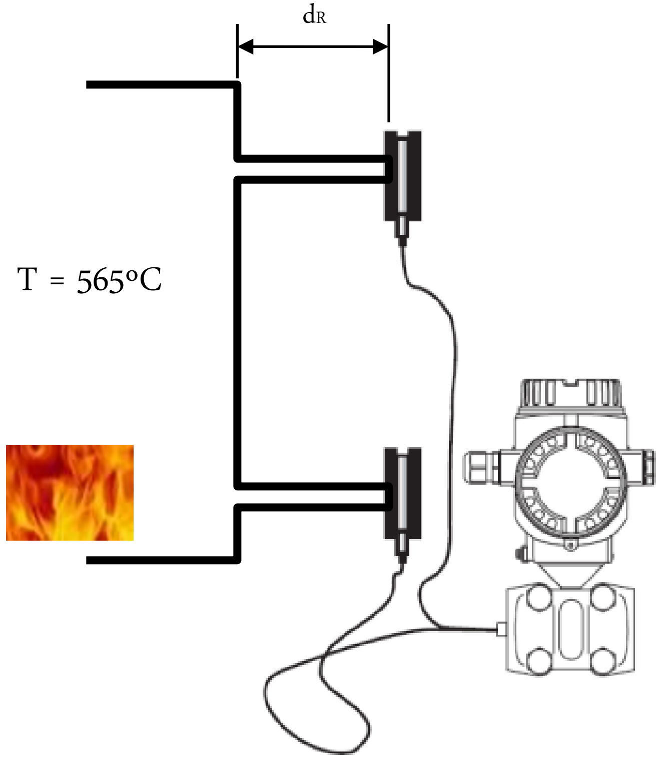
Thermal storage system

Level measurement hot salt vessel

B.3) Differential pressure

b.3.1) Excess temperature at diaphragma (temperature max.: 400ºC).

The solution is to separate the diaphragma from the process to cool the liquid.



Mind the composition of the fluid: 60% NO_3K and 40% NO_3Na, melting points is 225ºC. Depending on distance between diaphragma and process, the liquid may harden within the capillaries.

Implement thermal tracing.

Mind possible density variation of the salt.

Thermal storage system

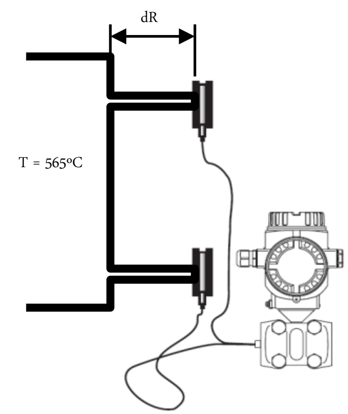
Level measurement. Hot vessel

B.3.1) recommended solutions:

- Correct cooling distance:

Cálculo de las distancias en función de las temperaturas		
Temperatura proceso	565	°C
Temperatura sensor	300	°C
Temperatura ambiente	-	°C
Distancia	**274**	**milímetros**

Cálculo de las distancias en función de las temperaturas		
Temperatura proceso	565	°C
Temperatura sensor	300	°C
Temperatura ambiente	50	°C
Distancia	**313**	**milímetros**



Note: these values are taken from empirical experiences in the process

A cooling distance d_R of 300mm is recommended

- Use a thermal braided system to ensure that temperatures in capillaries never fall below 225ºC (identical for HTF).

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Thermal storage system

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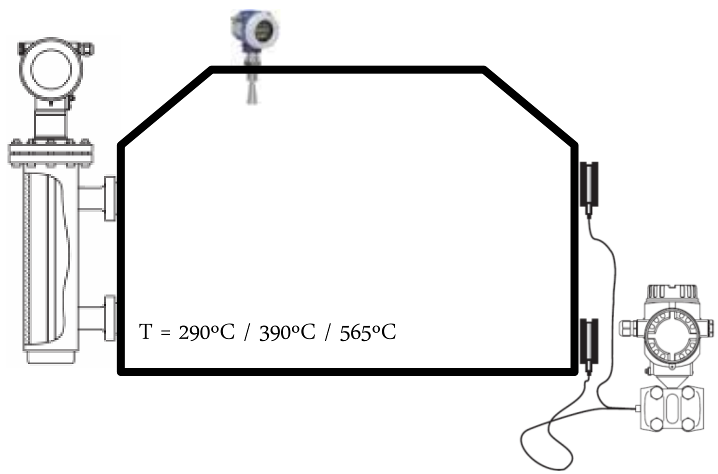
Level measurement. Summary



Cold salt vessel: (290°C)

a.1) Radar non-contact: **OK**

a.2) Guided Radar: **OK**

a.3) Differential pressure: **OK**

Hot salt vessel: (390°C / 565°C)

a.1) Radar non-contact: **T < 400°C: OK**

T > 400°C: NOT recommended

a.2) Guided Radar: **T < 400°C: OK**

T > 400°C: no solution with guided radar

a.3) Differential pressure: **OK**

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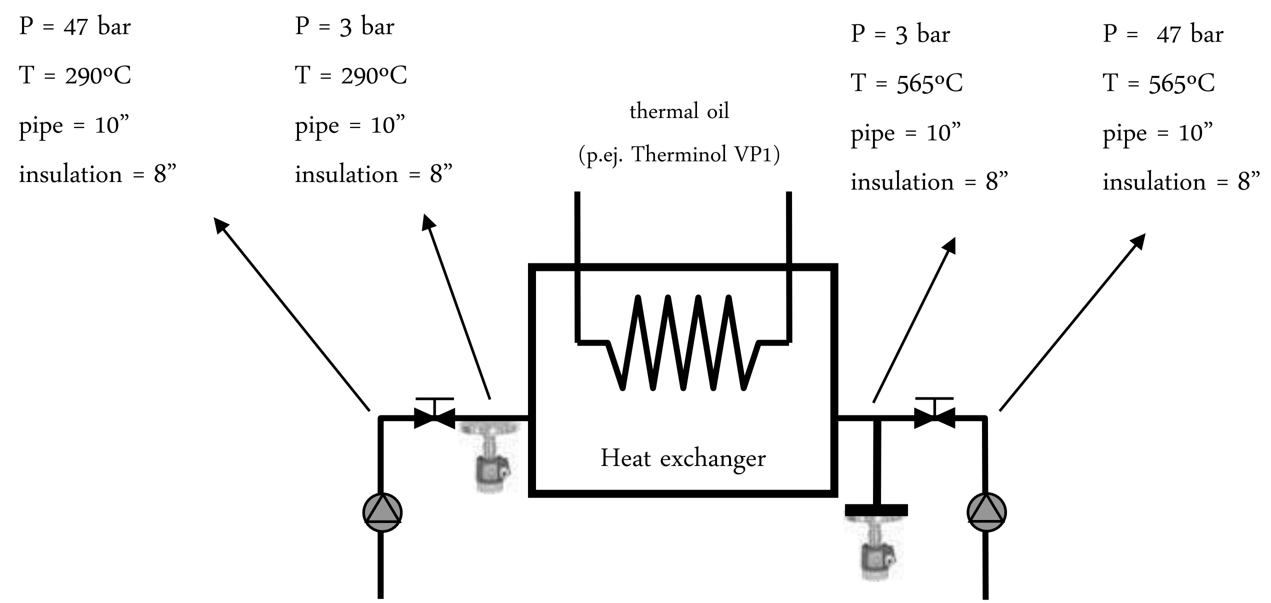
Pressure measurement: discharge of control pump and control valve



A) in the hot salt pipeline, a temperature spacing is required to reduce process temperature below 400 ºC, together with a thermal braided system to avoid hardening

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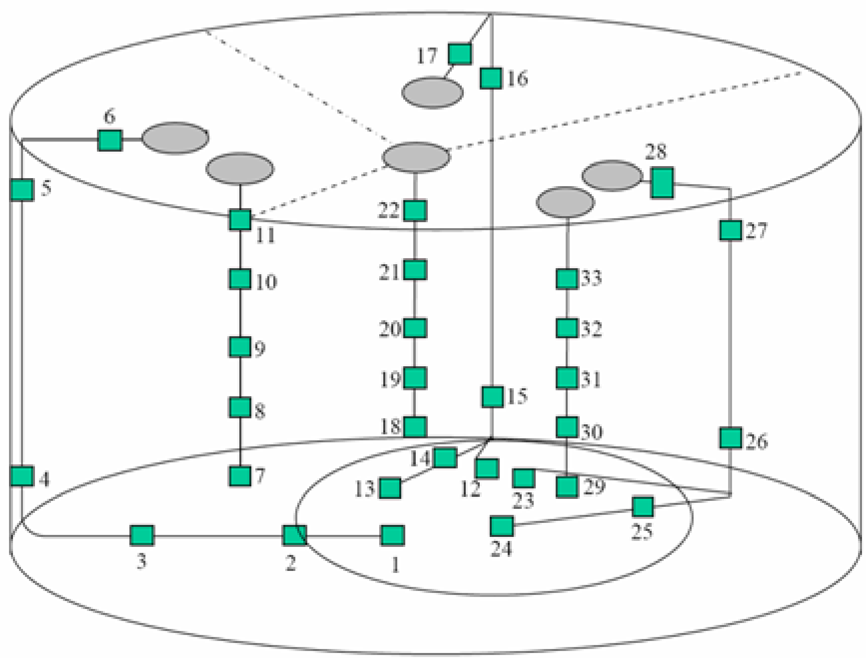
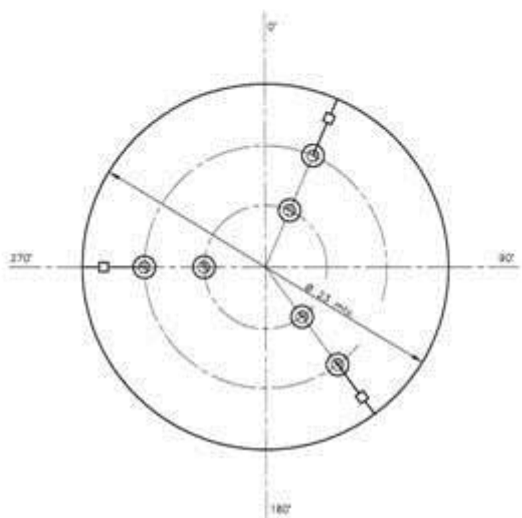
Temperature measurement





Thermal storage system

Temperature measurement

Medium: liquid salt (60% KNO_3 + 40% $NaNO_3$)

Process temperature

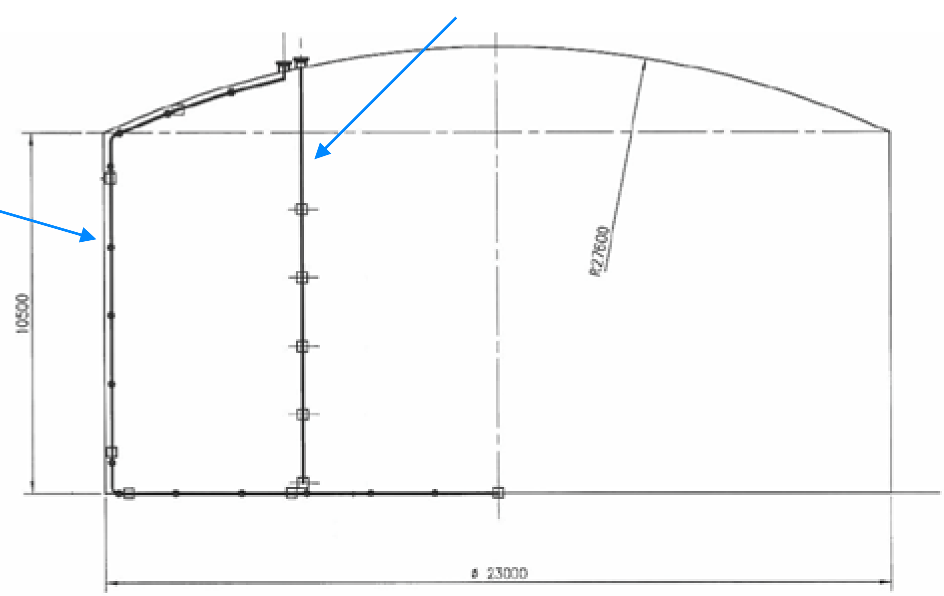
Cold vessel: 290°C

Hot vessel: 390°C – 565°C*

Process pressure: Approx. +40 mbarg

Multipoint sensor because of temperature variation within the vessel

Multipoint sensor in order to measure internal wall temperature and control crystallization of salt.



***Note:** 565°C is valid in case of central tower technology.

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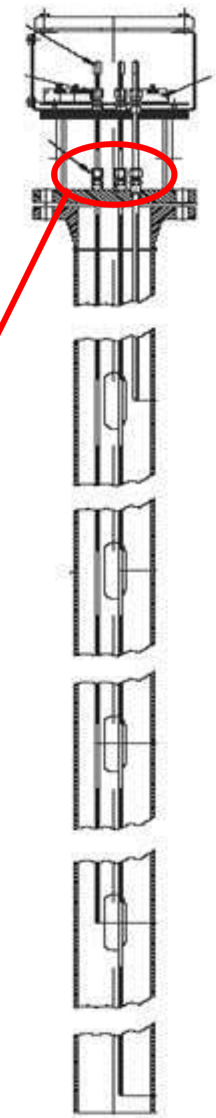
Temperature measurement

Temperature variation:

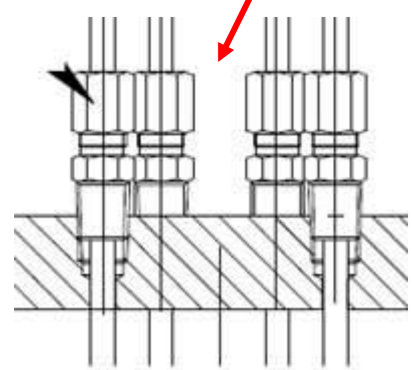
In order to control temperature variation in salt vessel, a multipoint sensor is used, which is guided in a stilling well.

The stilling well contains leveling holes.

In the hot salt vessel AISI 321 should be used



Extractible sensors are used in order to exchange during operation.



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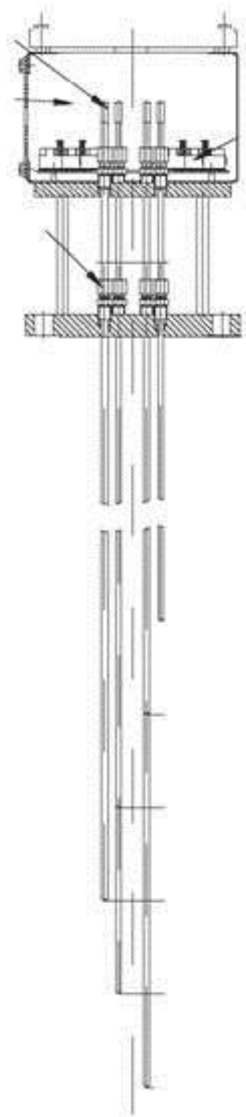
Temperature measurement

Crystallization on the tank wall:

The tank wall is thermal isolated to minimize the salt energy losses.

Because the salt crystallization temperature is around 250°C, this temperature needs to be avoided.

This is the most critical point in the cold salt tanks.



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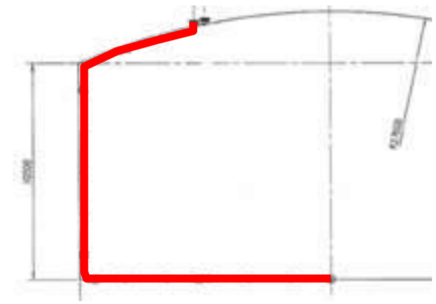
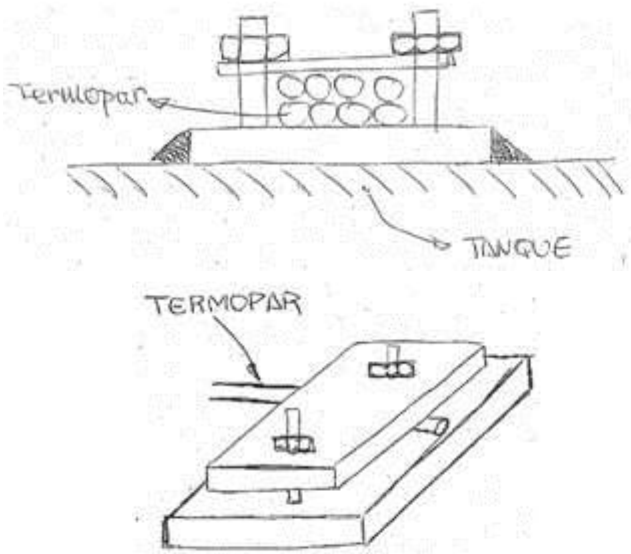
Temperature measurement

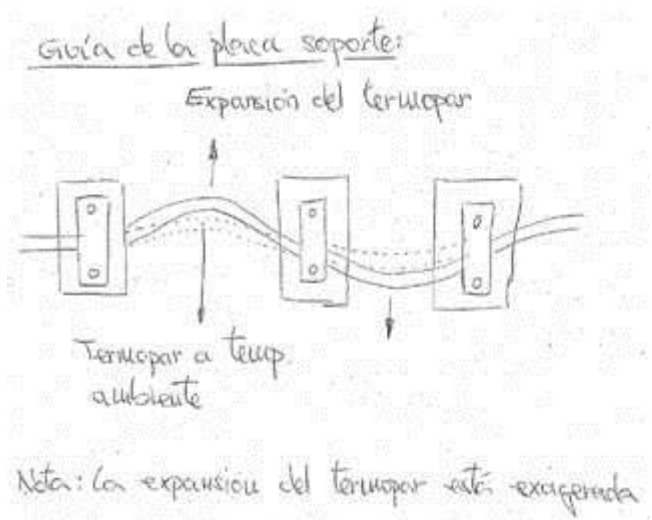
Fixation of the sensor to the tank walls.

´The multipoint temperature sensors could measure up to 40m at 25°C, but at 565°C the expansion of the sensor could reach more than 10%.



Therefore the fixation of the sensor needs to be flexible permitting the expansion of it. Recommendation:





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Surface temperature measurement for the control of the crystallization:

Example / Idea

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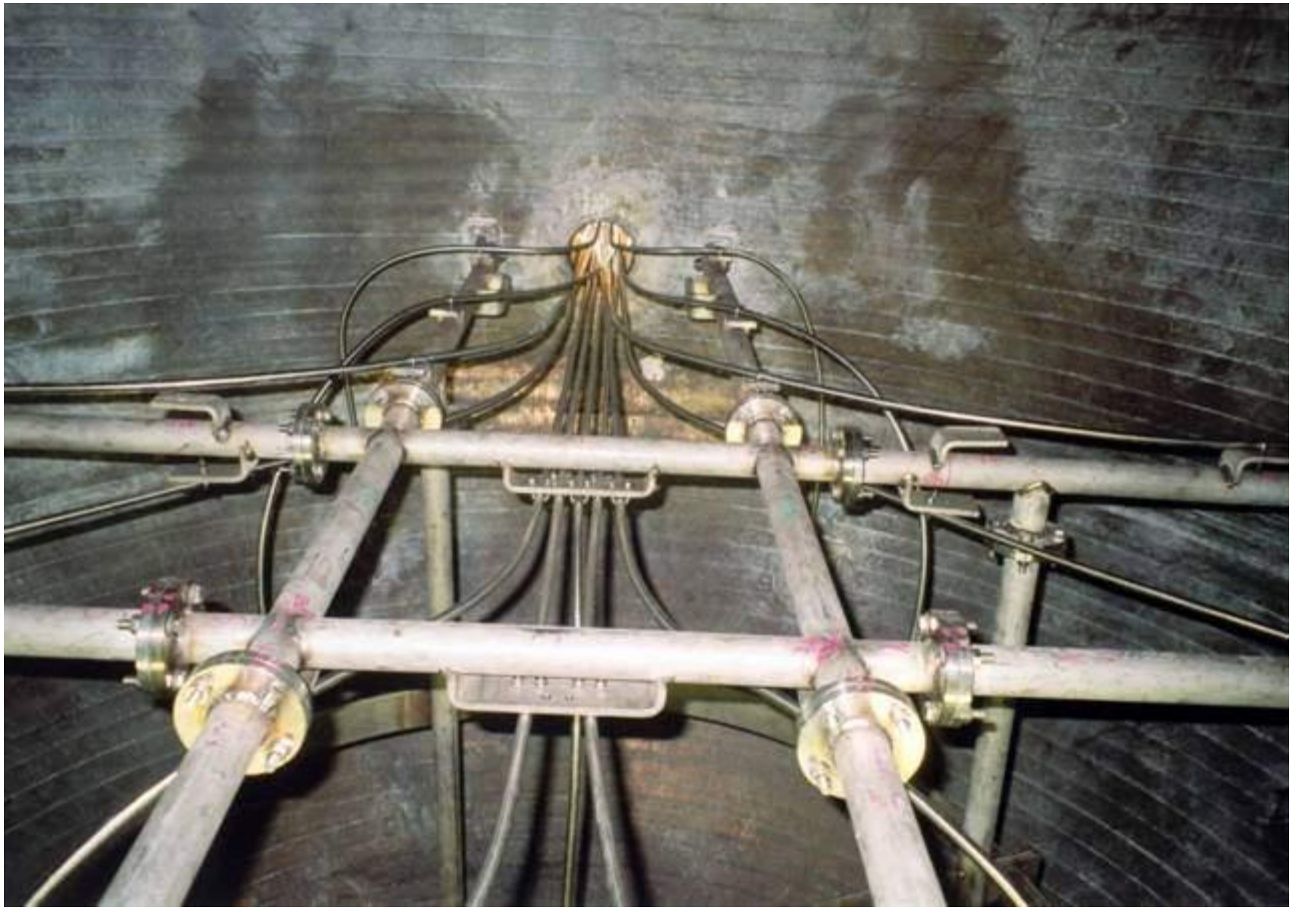
Surface temperature measurement for the control of the crystallization:

Example / Idea



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Solar thermal power plant
Competence in Power & Energy
W@M – Life Cycle Management

Surface temperature measurement for the control of the crystallization:

Example / Idea

Biogas Competence

Biogas energy measurement

CARBOSYS
CDM – Solution

Biodiesel Competence

Bioethanol Competence

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Solar Thermal power plant

3.1.4. Power unit

Endress+Hauser
People for Process Automation

Endress+Hauser

Power unit

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Biogas energy measurement
CARBOSYS CDM – Solution
Biodiesel Competence
Bioethanol Competence
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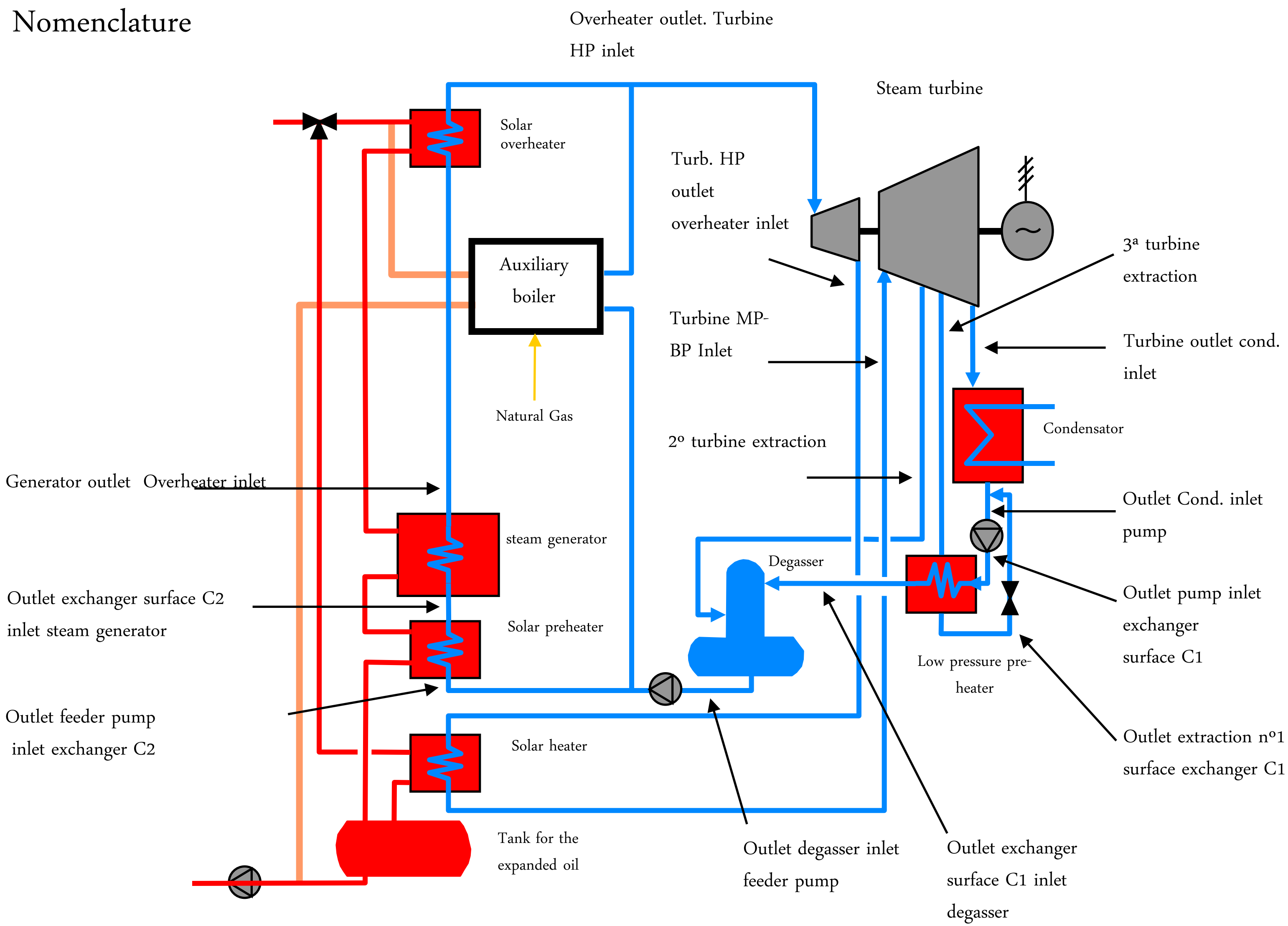
Nomenclature



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Power unit

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Biogas energy measurement
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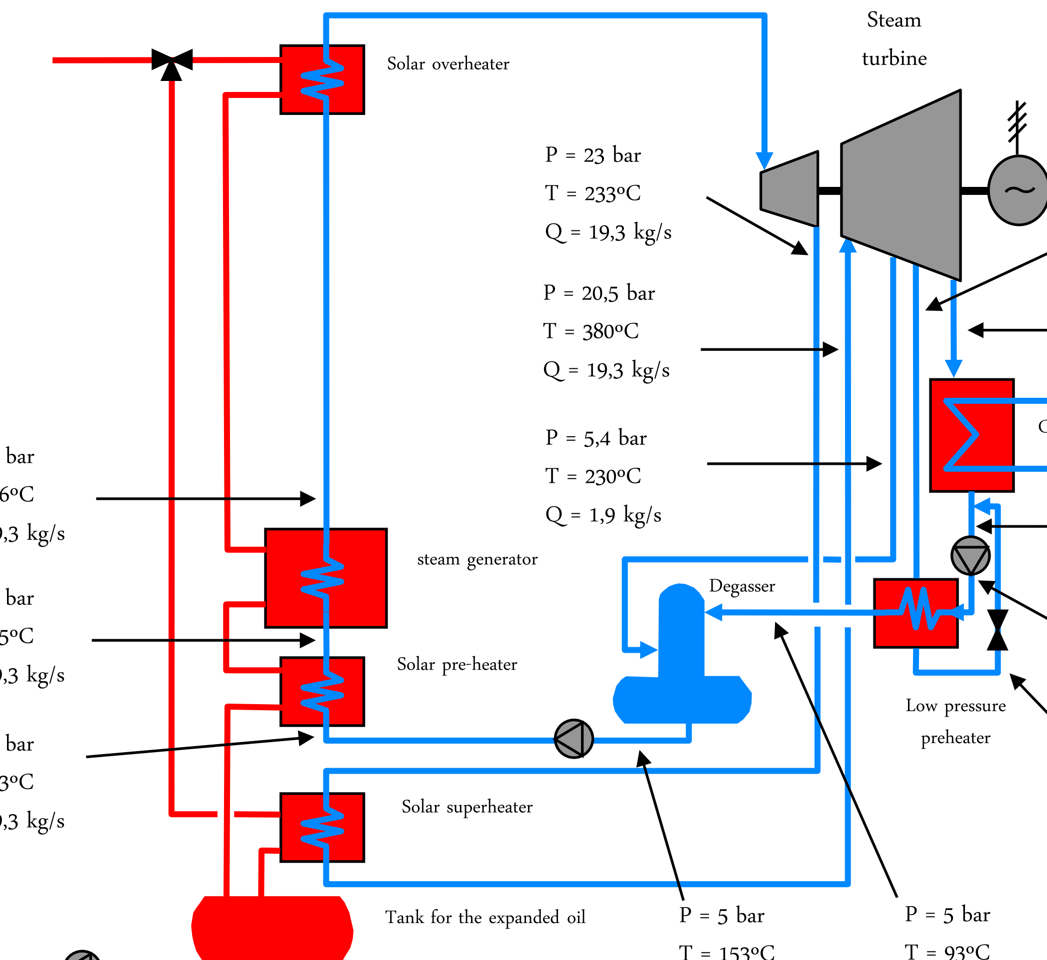
Process values (20 MWh)



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Power unit

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Biogas energy measurement

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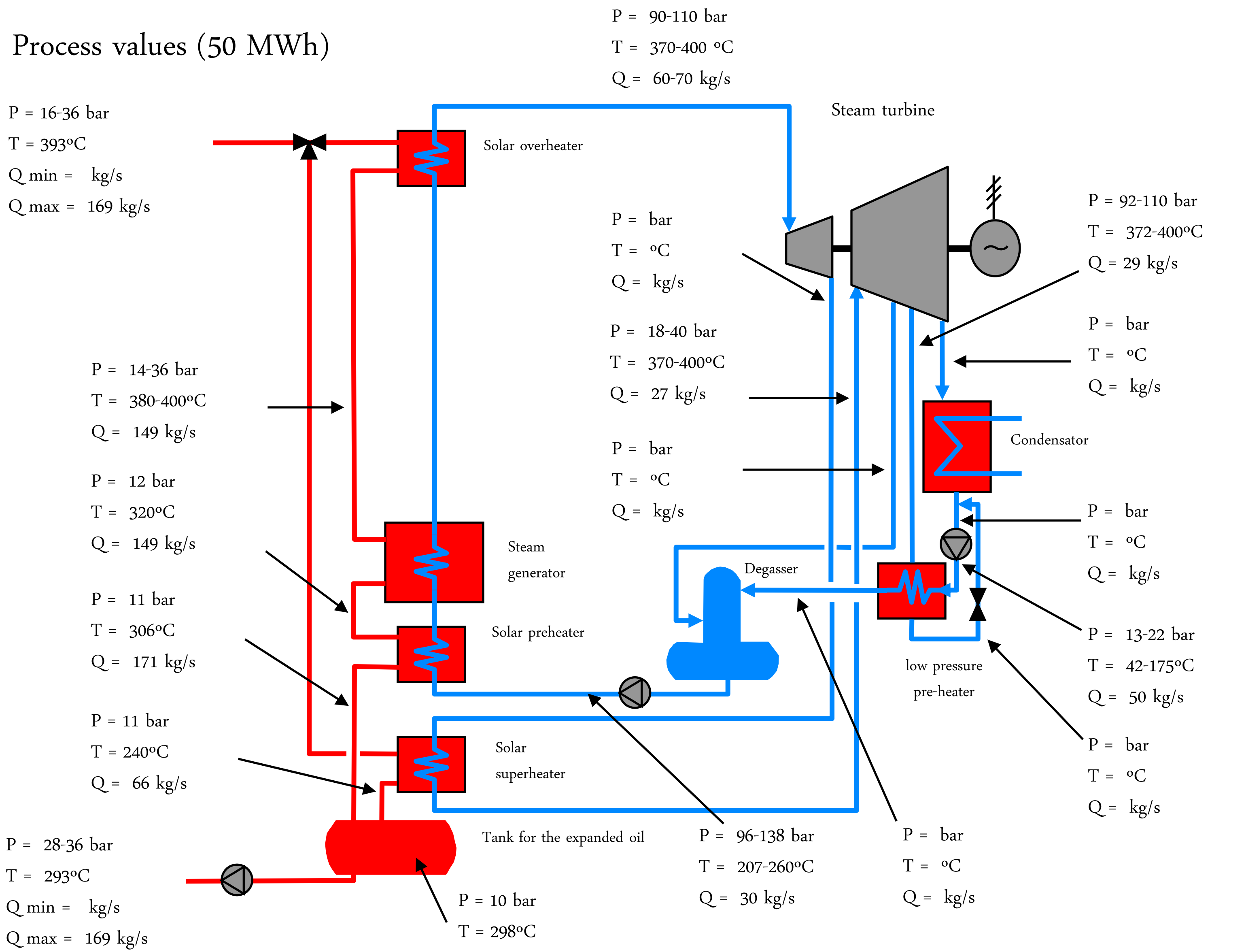
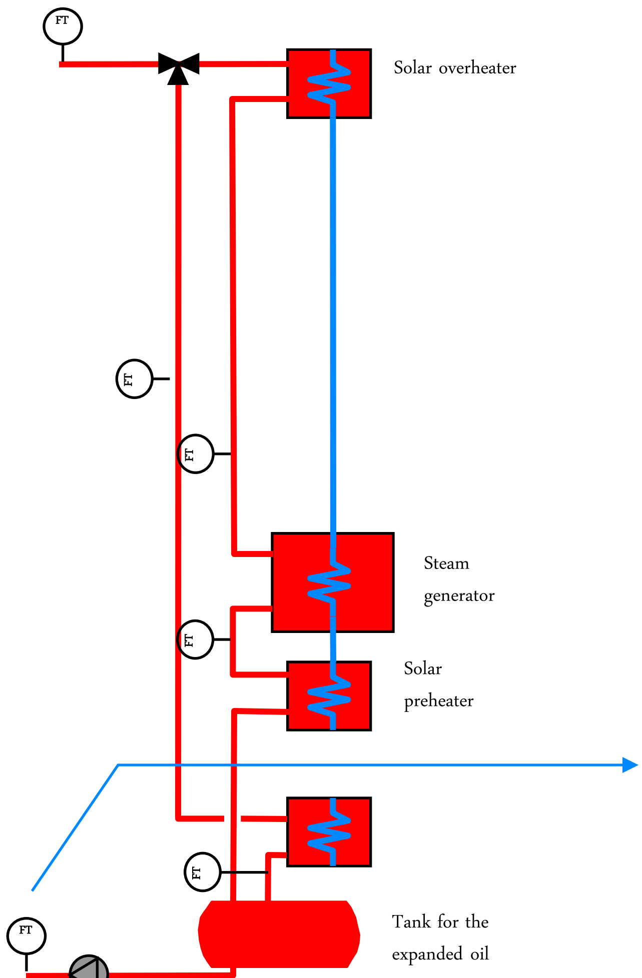
Process values (50 MWh)



Endress+Hauser

Power unit: flow measurement (HTF - thermal oil)

Measurement circuit



The flow measurement is done in the principal line to the solar field (32” pipe) as in different points though out the exchanger circuits.

The measurement in the solar field pipe (32”) is possible only using a Venturi pipe with thermal traceability (T > 12ºC).

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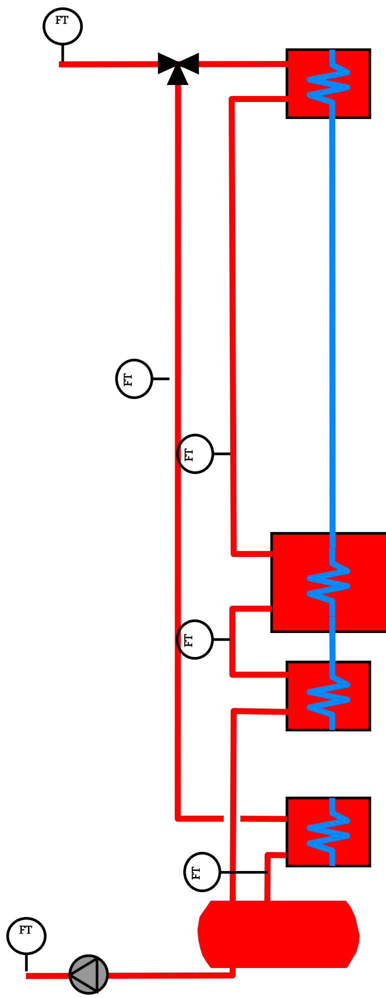
Power unit: flow measurement (HTF - thermal oil)

Measurement circuit



72F**-S*1A*********

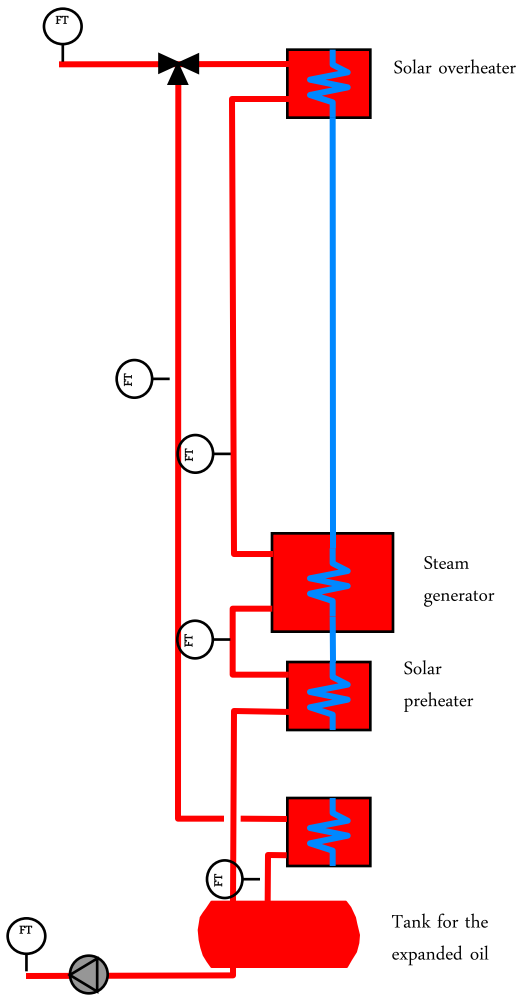
Alternative: DP Flow

in the rest of the circuit and always when the diameter are lower than 12”, is possible to use a Vortex flowmeter, otherwise a venturi/deprimógeno.

- temperatures up to 400ºC (sensor HT)
- Flanges ANSI. It is possible that the customer over engineered the flanges without a necessity.
- Up to 600 lbs Flanges we are expensive compared to flanges in DIN.
- 10” pipe and flanges classes 600 lbs → TSP
- Calorifugado: 8”

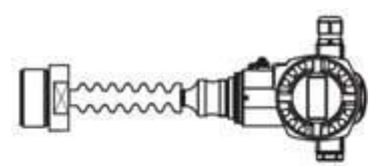
Power unit: pressure measurement (HTF - thermal oil)

Measurement circuit

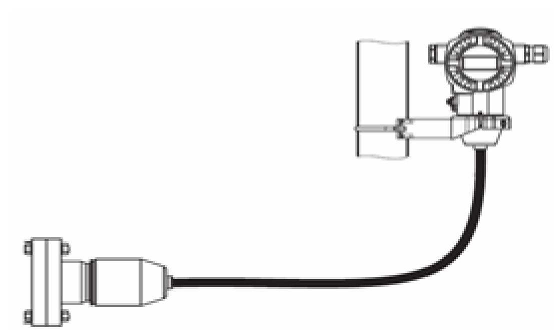


For the pressure measurement must be used high temperature oil, with two options:

A) with extension neck: Not recommended solution.



B) with capillary extension **recommended Solution.**



In this case it is necessary to make tracing of the capillary to avoid freezing it when the temperature is below 15°C

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Power unit: level measurement (HTF - thermal oil)

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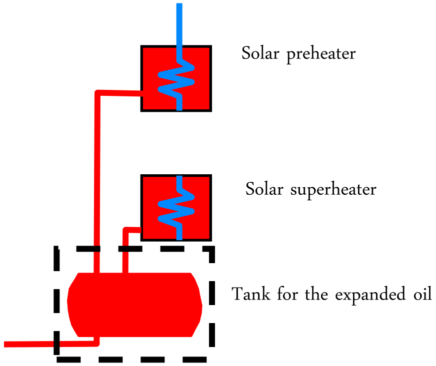
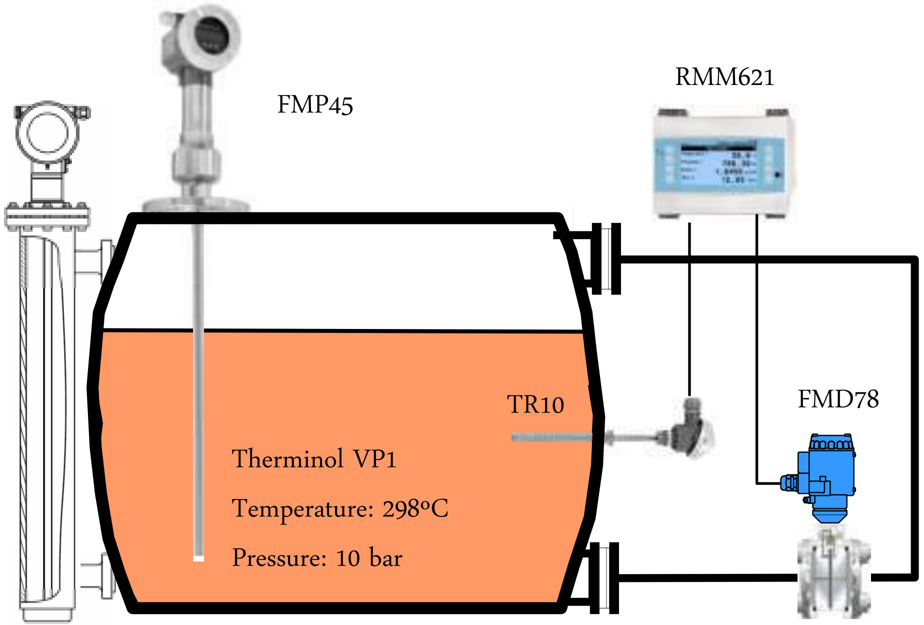
Tank for the expanded oil



Guided Radar: recommended solution

Different to the simple radar instruments, a guided radar device does not have a problem if the dielectric constant is too low at 300°C. It is the most recommended level measurement for expanded thermal oil tanks.

The measurement could be done directly in the tank or through a Bypass installation with temperature tracing.



Note: Extresol 1 and 2. The client needs two independent level measurements.

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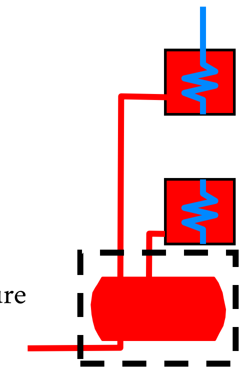
Power unit: level measurement (HTF - thermal oil)

Tank for the expanded oil



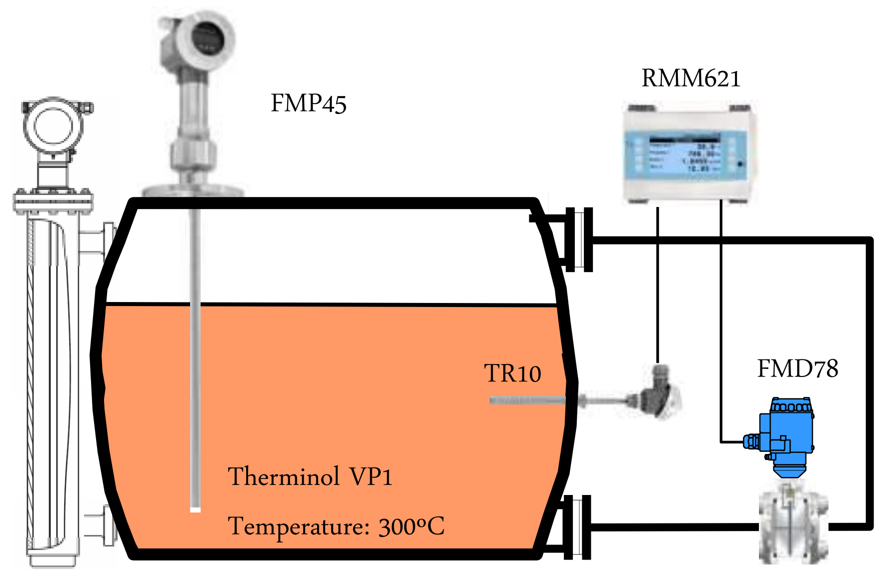
Differential pressure: NOT recommended solution

Because the thermal oil shows a variable density as a function of the temperature, it is necessary to compensate the measurement when it is done through a differential pressure device. Using a Temperature-density table in a RMM621, together with the level measurement, is possible then to get the compensate level of the tank.

Variation of th density

ºC	**kg/m3**
270	848
280	838
290	828
300	817
310	806
320	796

A variation of 20°C, means an additional error of 3% of the level measurement at the DP device.



Note: Extresol 1 and 2. The client needs two independent level measurements.

Power unit: level measurement (HTF - thermal oil)

Level measurement in the heat exchangers of the thermal oil

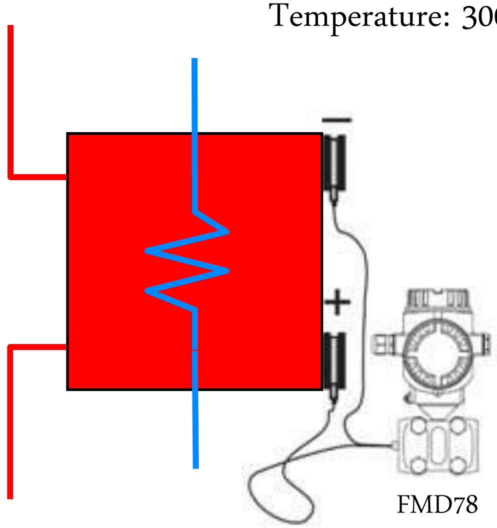
The capillary differential pressure transmitter offer a correct solution. An alternative solution is the utilization of a differential pressure transmitter with pipe installation and condensation chambers (done by the customer), together with a thermal traceability to avoid to reach the temperatures under the fusion of the oil (15°C)

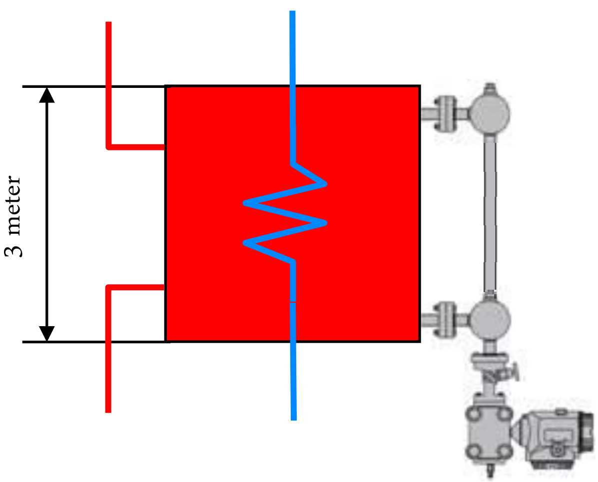
Recommended solution

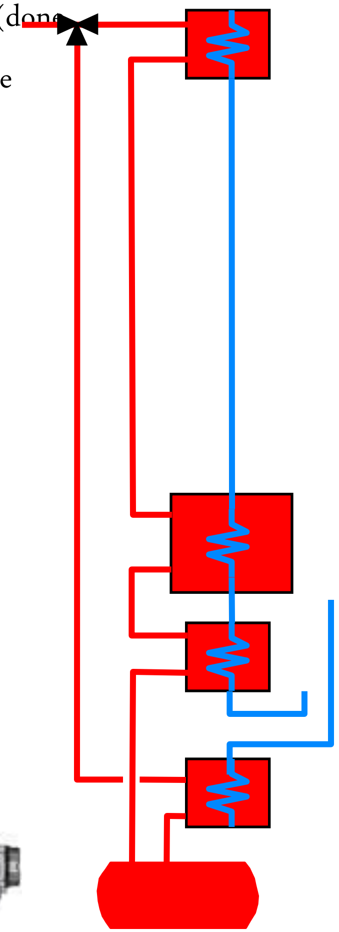
Pressure: 120 bar

Temperature: 300 – 400°C

Not recommended solution







Note: Extresol 1 and 2

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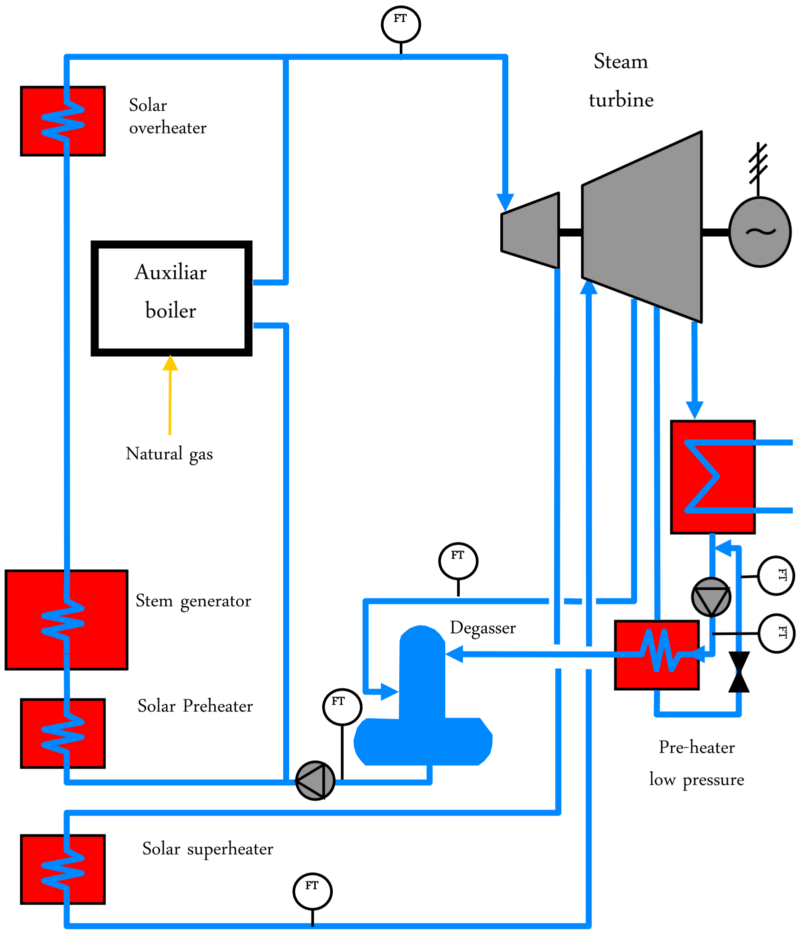
Power unit: flow measurement (steam + water)

Measurement circuit



72F**-S*1A********

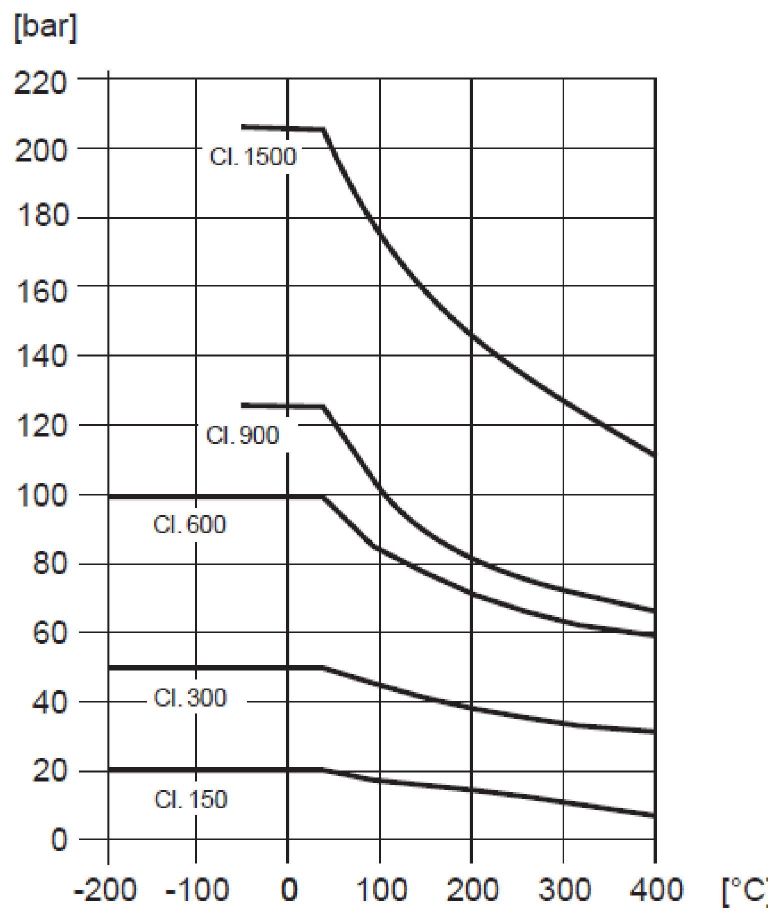
Alternative: DP Flow

steam: The principal limitation of vortex is the pressure of the line, which is near to 100 bars. It is available flanges for 1500 lbs.

In case a vortex is not suitable, the alternative is an orifice plate device with flanges soldered to the process. **Water:** injector / venturi / electromagnetic (attention to the conductivity)

Endress+Hauser

Pressure-temp. curve to ANSI B16.5, stainless steel



Solar field instrumentation - flow

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- Preferred solution in the market: Ultrasonic clamp-on (Panametrics)

  Reason: it is not required to cut the pipe for installation

  Price: 25.000€ - 30.000€

- More economical solution of Endress+Hauser:

Vortex:

- if you require 0,7% accuracy, vortex has 0,7%
- If you require 220V power supply, vortex has 24V.
- There are piplines up to 20”. Vortex has max. 12”.
- For DN of 200 and above and ratings of 900#/1500#/2500#, TSP is expensive.

Note: Kuraymat, Yokogawa delivered a welded vortex version which is much cheaper

Venturi pipeline

- More expensive then ultrasonic flow meters
- It is required to trace thermally up to pressure sensors
- Hardening temperature of oil is T= 12°C

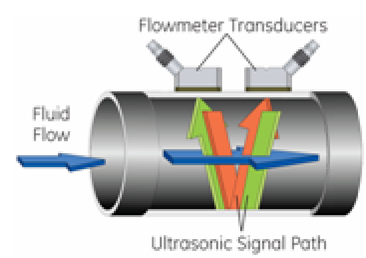
Endress+Hauser

Solar field instrumentation - flow

Competition

- Krohne
  - Model: UFM530HT (high temperature)
  - Specified accuracy: 0,5% reading
  - Price: 20.000 €
  - Diameter: DN80 (3”) → PN40 (600 lbs)
    DN300 (12”) → PN10 (150 lbs)
  - Designed pressure: PN10 – PN40
  - Designed temperature: 440 °C

- Panametrics
  - Model: DF868
  - Ultrasonic up to 5 m (high temperature)
  - Specified accuracy: 1,5% reading
  - Price: 25.000 – 30.000 €
  - Max. pressure: 200 barg
  - Max. temperature: 600°C



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Solar field instrumentation - flow

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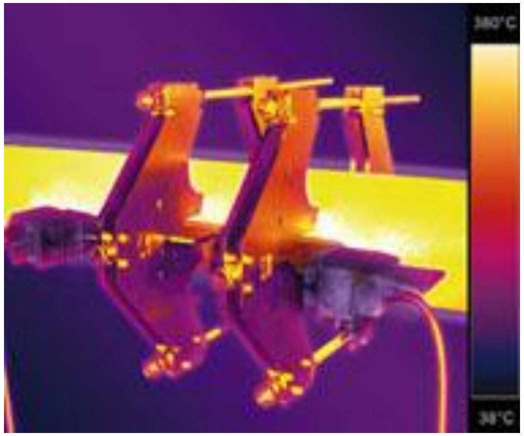
Competition

- Flexim
  - Model: WI-400
  - Specified accuracy: % reading
  - price: ? €
  - immersion length: 40…1000 mm
  - Designed pressure: barg
  - Designed temperature : 400ºC



- FCI (Fluid Components International LLC)
  - Model: FCI FLT93S
  - Sistema calorimétrico
  - Specified accuracy: 0,5% reading
  - price: 2.500 €
  - immersion length: up to 18”
  - Designed pressure : 240 barg
  - Designed temperature: 454ºC

FLUID COMPONENTS INTERNATIONAL LLC

Power unit: flow measurement natural gas (boiler)

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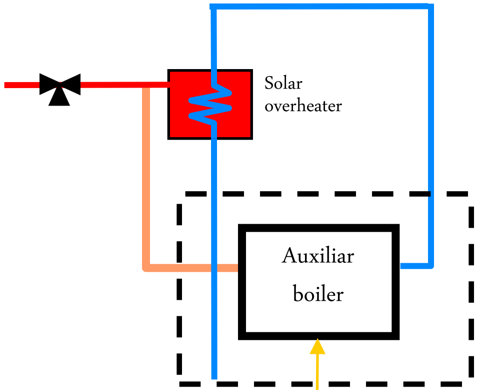
Measurement circuit

The natural gas flow measurement, could be done with a vortex device, with a coriolis mass flowmeter or with a Thermal mass flowmeter (depending of the installation layout of the equipment). For a vortex application it is necessary to compensate the pressure and the temperature using a RMC to calculate the mass flow required for the boiler.



Flow measurement thermal mass

Water flow measurement for the boiler

Due to the low conductivity of the inlet water, it is recommended to use a Vortex device (73F). The 73F, include a temperature sensor, required if is necessary to calculate the thermal efficiency of the boiler.

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Solar Thermal power plant

3.1.5. Water treatment plant

Endress+Hauser

Water treatment plant

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General information:

The plant required 4 different types of water for his operation:

- Filter
  - inlet water for the refrigeration towers
  - water for service
  - PCI system against fire
- Osmotic water
  - to clean the mirrors
- Desmineralized water
  - for the operational cycle
  - Close system for the refrigeration
- Potable
  - consumable for the plant (¿potable system needed?)

Water treatment plant

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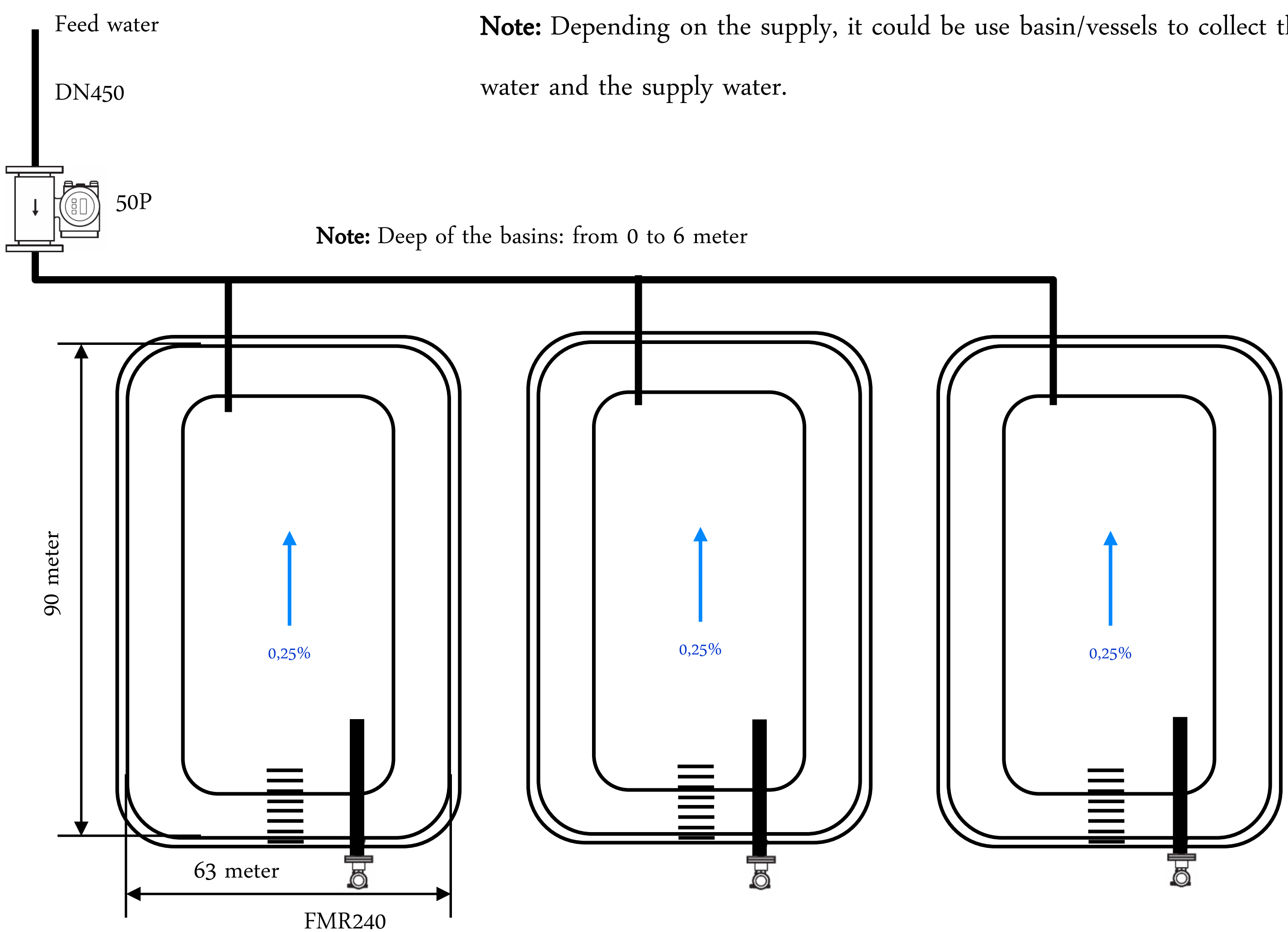
Flow and Level measurement in regulation basins

Note: Depending on the supply, it could be use basin/vessels to collect the rain water and the supply water.



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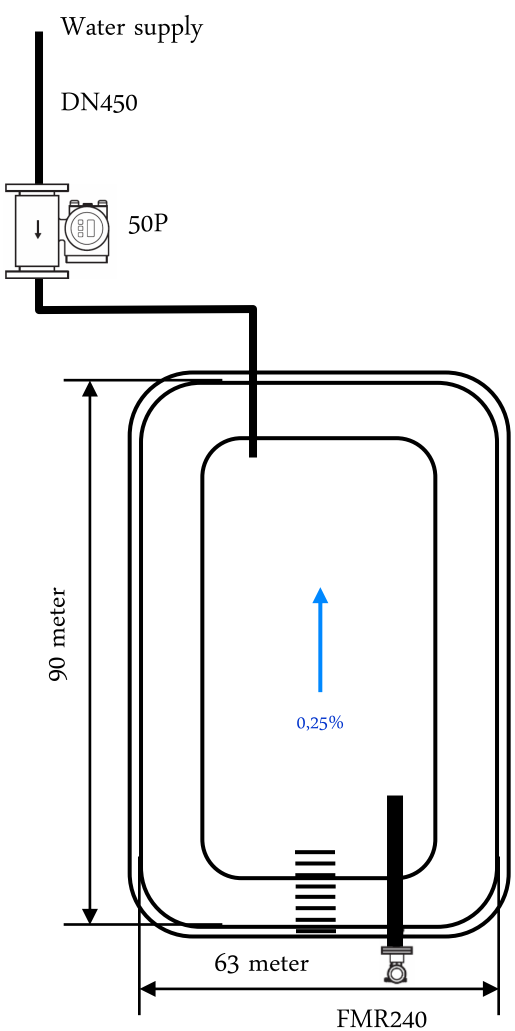
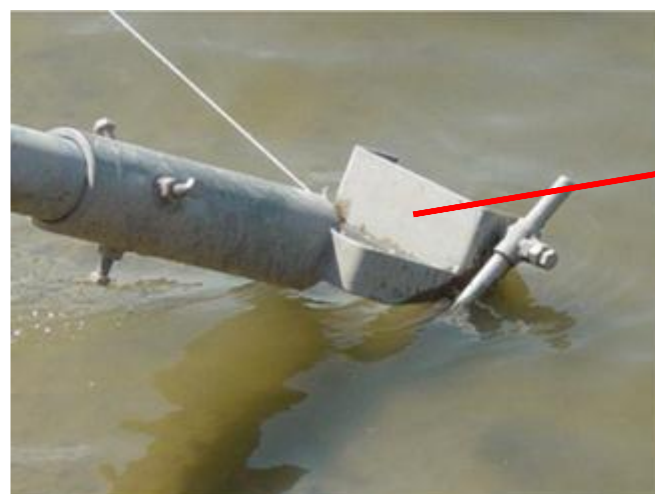
Water treatment plant

Flow and Level measurement in regulation basins



Micropilot FMR 240 installed with 30°with a 2" pipe.



Reflection point when the basin is empty.