

HOT OIL SYSTEM DESIGN GUIDE

FIRST EDITION, June. 2004

머 리 말

본 Guide Book은 Vendor data를 근간으로 팀 내의 각종 자료를 재 정리 함으로서 공정 엔지니어가 Hot oil의 선정 및 System 설계를 용이하게 함과 System check 하는데 도움을 주고자 작성 되었다.

Vendor 자료의 내용에 근거하여 Hot oil의 data를 가능한 한 일목요연하게 정리를 하였고 Hot oil system의 각 장치들에 대한 설명을 가능하면 쉽고 설계에 직접적으로 도움이 될 수 있도록 최근 개인적으로 수행한 Project 중에서 대표적인 시스템들을 참조하여 작성을 하였으나, 향후 새로운 자료들을 계속적으로 접수하여 Update를 지속적으로 할예정입니다..

본 Guide Book이 Hot oil system의 설계 수행에 실질적인 도움이 되길 바라며, 작성과정에서 많은 조언을 주신분들에게 감사 드립니다.

2004년 11월 19일

Content

1. INTRODUCTION

- 1.1 General
- 1.2 Definition

2. HOT OIL SELECTION GUIDE

- 2.1 General consideration to hot oil selection
- 2.2 Hot oil system and application of hot oil

3. COMMERCIAL HOT OIL DATA

- 3.1 Commercial hot oil evaluation
- 3.2 Typical hot oil selection
- 3.3 Detailed commercial hot oil data (refer to attachment)

4. HOT OIL SYSTEM DESIGN GUIDE

- 4.1 Heater
- 4.2 Expansion Drum (Surge drum)
- 4.3 Circuit
- 4.4 HTF storage
- 4.5 Trim Cooler, Rundown Cooler
- 4.6 Heat Consumer
- 4.7 Pumps
- 4.8 Instrumentation and control
- 4.9 Material Selection

5. OPERATIONAL REQUIREMENTS AND PRECAUTION

- 5.1 Starting the Plant
- 5.2 Supervision of Operation
- 5.3 Maintenance of Plant

6. REFERENCE HOT OIL SYSTEMS

- 6.1 Hot oil system summary of GSP-5 project
- 6.2 Hot oil system summary of Songkhla GSP-1 project
- 6.3 Hot oil system summary of LAB project
- 6.4 Hot oil system summary of 이집트 칼다 project
- 6.5 Hot oil system summary of 삼성석유 TA/PTA project

7. REFERENCE

8. ATTACHMENT: VENDOR INFORMATION

DOW

Dow Product Guide
Equipment for Systems using dowtherm
Dowtherm, Syltherm Data
Dowtherm for Low Temperature Transfer
Dowtherm A, G, HT, J, MX, Q, RP, T, XLT
Dowtherm Q, RP – Product Technical Data
Syltherm 800, HF

DYNALENE

Dynalene 600, HT, SF

IMPERIAL OIL

Thermoil and Essotherm

MOBIL

Mobiltherm

MULTITHERM

Safety Issues for Thermal Fluid Systems
Multitherm Products
Multitherm 503, IG-1, IG-4, OG-1, PG-1

PARATHERM

A Comparison, Thermal Fluid vs. Steam
Fluid Degradation Problems with Improper Shutdown
Fluid Fouling Problems in Closed-Loop Temperature Control
How to Track the Performance of Heat Transfer System
Oxidation in Heat Transfer Fluids
Problems With Multi-Purpose Oils in Heat Transfer Service
Recommended Hot Oil System Components
Significance of Flash and Fire Points in Heat Transfer Fluids
Analyzing Your Fluid

Heat Transfer Fluid Tips
Draining, Flushing and Charging Your Thermal Oil System
Fire Prevention in Thermal Oil Heat Transfer Systems
Paratherm CR, HE, LR, MR, NF, OR

RADCO INDUSTRY

Technical Tip 1: Proper Maintenance can extend the life
2: Selecting High temp HTF, synthetic or hot oil
3: Saving system downtime
4: Expansion tank design
5: HTF service can extend fluid life
6: Starting HTF selection process

Xceltherm 445, 500, 550, 600, HT, LV series, MK1, XT

SHELL

Thermia Oil B

SOLUTIA

Therminol HTF Design Seminar
Therminol Selection Guide

Bulletin 1: Cleaning organic HTF system
2: In-use testing
3: HTF filtration – How and Why
4: Heat transfer system expansion tank design
5: Moisture Removal

Liquid Phase Design Guide

Vapor Phase Design Guide

System Design Data

써미놀 - 열전달매체의 장비 운용지침

Therminol 55, 59, 66, 72, 75, D12, FF, LT, VP-1, XP

1. INTRODUCTION

1.1 General

The most common heat transfer fluids are steam and water, and if the temperature is above the freezing point of water (0°C) and below about 175°C, the choice is usually between these two fluids. On the other hand, if the temperature of application is below the freezing point of water or above about 175°C, it is necessary, or at least desirable, to consider other fluids.

For temperature below the freezing point of water the most common heat transfer fluids are air, refrigerants such as halogenated hydrocarbons, ammonia, brines and/or solutions of glycol and water.

As temperature increase above 175°C, the vapor pressure of water increase rapidly, and the problems of structural strength for processing equipment becomes more and more severe. Thus with high temperature systems it becomes increasingly important to consider fluids with vapor pressures lower than water. That is a reason hot oil is required.

Hot oil system is high temperature heating system, used for industrial processes most often instead of steam, because of much higher operating temperatures at low operation pressure and because of significant less overall operation costs.

In the design of a high temperature organic heat transfer system, the engineer has two key problem areas to evaluate. These are:

- 1) The selection of the heat transfer media; and
- 2) The system design and selection of process equipment.

Comparison with steam boiler and hot oil heater

	Hot oil	Steam boiler
Operating pressure (based on 250°C)	0 bar or a little higher (safe)	Over than 100 bar (danger)
Water treatment	No need (cheap)	Need (expensive)
Winterizing	No need (pour point -30°C)	Need
Life cycle	Over than 15 years No corrosion	Short Corrosive
Temp. Control range	±0.5°C (sensitive)	Wider than ±0.5°C
Loss of heating medium	No	Vaporizing and trapping
Blow down	No	Continuous loss
Cost of invest	Relatively low	Expensive

1.2 Definition

Heat-transfer fluid (HTF), 열매체

Fluid capable of transporting heat energy within a specified temperature range in a closed circuit to heat or cool the system. In this design guide, the Heat Transfer Fluid is Hot Oil (Synthetic or Mineral Oil).

Liquid Phase System

Heat transfer fluid is used in the circuit without phase change, thus heat transferred by sensible heat of the fluid

Vapor-Liquid Phase System

Heat transfer fluid is used in the circuit with phase change, thus heat transferred by latent heat of the fluid.

Expansion drum (or Surge drum)

The drum to buffer the HTF volume difference between each conditions.

Drop tank (or dump tank)

A tank capable of holding the HTF inventory, in case of an emergency and/or maintenance drain of the circuit.

HTF system

All heaters, piping, pump, vessels, heat exchangers and auxiliaries that make up the closed circuit containing the HTF.

Heater

Heat energy producer in the system. Applications include furnaces and (waste) heat recovery units(HRU), both fired and unfired.

Maximum allowable bulk temperature (MABT)

The maximum bulk temperature of the HTF allowed anywhere in the circuit.

Maximum film temperature

The maximum temperature to which the HTF may be subjected anywhere in the system. The highest temperature is usually found at tube inner wall of the heater, the level being determined by the fluid bulk temperature and the heat flux impinging on the tube.

Minimum application temperature

The lowest bulk temperature at which the HTF can be used; i.e., pumpability limit, pour or crystallization point.

Return temperature

The temperature that the HTF returns on the return header after heat transferred to the system.

Supply temperature

The temperature that the HTF supplies on supply header before heat transferred to the system.

2. HOT OIL SELECTION GUIDE

2.1 General consideration to hot oil selection

Thermal fluids have been developed which can offer some advantages over the alternative carriers. The properties of an ideal thermal fluid are:

- 1) Not-toxic, non-flammable and non-corrosive
- 2) Low pour point or freezing point
- 3) Low vapor pressure (liquid system), high boiling point
- 4) No thermal decomposition in the working temperature range
Some hot oils, if those are contacted with water, humid or oxygen, become degrade to shorten life. Especially silicone based heat transfer fluid could decompose into light volatile components. Hot oil composed of Nitrite could explode when it reacts with organic compounds.
- 5) High film heat transfer coefficient (high thermal conductivity and specific heat capacity, low viscosity index)
- 6) High latent heat of vaporization (vapor systems)
- 7) High maximum working temperature

The engineer needs to select the thermal fluid that will perform satisfactorily and safely at the process temperature required. To do this, the engineer can draw on his past experience or make the comparisons between the well-known fluid manufacturers. The important factors he must consider in selecting a high temperature heat transfer fluid can be categorized into the following four areas.

Toxicity and Environmental Ecology

Toxicity and ecology are, of course, extremely important from both an operating and a process standpoint. There is always a chance that a heat transfer fluid may find its way through packing glands on valves, pumps, heat exchangers, etc., hence, operators, maintenance men, and surroundings will be exposed to the fluid. More ecological information for evaluating this subject is being made available from many fluid manufacturers today.

Corrosiveness to Materials of Construction

In general, a heat transfer fluid should be non-corrosive to mild steel. Otherwise, the equipment cost will be prohibitively high. It should be noted that all of the chlorinated compounds recognized as heat transfer fluids, are essentially non-corrosive to mild steel as long as all traces of water are kept

out of the system and the fluid is not overheated.

If halogenated materials are overheated either by bulk temperature higher than the recommended maximum temperature or by localized hot spots in furnace, hydrogen chlorides gas will be evolved. The hydrogen chloride gas will remain relatively non-corrosive to mild steel as long as the system kept absolutely dry, but if traces of water are present, the hydrochloric acid will be formed extremely corrosive, particularly at elevated temperatures. Chlorides can also cause a stress corrosion cracking of stainless steels if water is present.

Flammability

Lack of flammability is always vital whenever there is a chance that a fluid may not be completely separated from all sources of ignition. Some of the chlorinated compounds such as chlorinated biphenyls are fire resistant because they will not support combustion due to the chlorination. However, if they are heated to a sufficient high temperature they exhibit a flash point and an explosive range. They will burn if subjected to the ignition conditions encountered in the fire box of a fired heater. Thus, organic fluids must not be exposed to a source of ignition.

While non-chlorinated heat transfer fluids will burn, this factor presents no problems if they are contained properly. If, due to some unusual occurrence, they leak from the system into a space other than the fire box of a furnace, they will almost invariably, if not always, be below their auto ignition temperatures before they come in contact with air. Thus there must be a source of ignition before leak outside a fire box can be serious. Moreover, combustion requires a mixture of air and vapors having a concentration within the flammability limits of the fluid. For continued burning, the liquid must be at temperatures higher than its fire point.

Thermal Stability and Engineering Properties

Several generalizations can be made about thermal stability and degradation of organic heat transfer media.

- 1) In comparing classes of compounds, aromatics materials have thermal stability generally superior to aliphatic compounds.
- 2) For commercial products, the recommended maximum operating temperature is a rough measure of relative thermal stability.
- 3) Polymer formation is detrimental particularly if the polymerization is exothermic. Polymers increase the viscosity of a fluid and promote carbonization leading to inefficient and potential failure of the heater.
- 4) Fluid degradation should produce a minimum of volatile materials such as hydrocarbons. These decomposition products will increase operating

losses and they are a safety hazard (fire and toxicity) in a vented heating loop.

- 5) Degradation should not produce reactive or corrosive, toxic, and they accelerate fluid breakdown at high temperatures. Cracking products such as olefins will polymerize under operating conditions.
- 6) Oxidative stability can be an important factor if air is present at high temperatures.

2.2 Hot oil system and application of hot oil

2.2.1 Hot oil system

Liquid Phase System

Liquid phase heat transfer fluids operate over the broad temperature range of -85 °C to 385 °C and are designed to be used in non-pressurized systems. A major advantage of liquid heat transfer is lower cost installation and operation. Capital cost is reduced by elimination of large-diameter piping, safety valves, steam traps and water treatment facilities. Operating cost is reduced by low maintenance requirements and reduced makeup.

- (1) No phase change, so that the temperature is controlled easily.
- (2) No temperature difference from pressure change
- (3) Heat transfer evenly distributed and suitable for multiple users through the main header to branches.
- (4) Minimize vent loss against thermal degradation when operation in the temperature range selected.
- (5) Liquid phase system gives small investment cost because of low design pressure and small size equipment required.

Liquid/Vapor System

Liquid/vapor phase heat transfer fluids offer a broad operating temperature range and uniform heat transfer. Other major benefits include precise temperature control and low mechanical maintenance costs. Also, a heat transfer system that utilizes a vapor phase medium requires less fluid than a comparable liquid phase system because the equipment fills with vapor instead of liquid.

- (1) Large heat transfer capacity by using latent heat
- (2) Less hot oil inventory within the system.

2.2.2 Types and application of heat transfer fluid

Quoted maximum fluid temperatures vary, but most are around 350 °C, allowing them to be used for process temperatures up to 300 °C. The atmospheric boiling points of these fluids are in the range 260 – 340 °C, so the system must be pressurized, but vapor pressures are generally only 1 – 2 barg at working temperatures.

The system is pressurized by a nitrogen blanket in the expansion tank, which also prevents air from coming into contact with the fluid; dissolved oxygen is more of a problem with the synthetic aromatic fluids than with

the mineral oils, and is made worse by the higher operating temperatures. The synthetic aromatics generally have better low temperature performance than mineral oils. These fluids cost between two and two and a half times as much as the mineral oils.

For temperatures up to 1000°C liquid metals like mercury, sodium and sodium potassium alloys have been used. Nuclear power plant designers may have no alternatives, but for ordinary process industry applications the disadvantages of liquid metals are obvious.

Type	Brand name	Manufacturers
Mineral oils:	Mobiltherm 605	Mobil
	Essotherm	Esso
	Transcal 65	BP
Synthetic aromatics:	Diphyl DT	Bayer
	Dowtherm Q	Dow
	Syntrel 350	Exxon
	Marlotherm L	Huls
	Santotherm 66	Monsanto
	Gilotherm	Rhone-Poulenc
	Transcal SA	BP
Diphenyl-diphenyl oxide:	Diphyl	Bayer
	Dowtherm A	Dow
	Thermex	ICI
	Santotherm VP-1	Monsanto
Silicones:	Syltherm 800	Dow

General liquid phase heat transfer fluid

- (1) General range of application is 150~300°C
- (2) Mostly refined MINERAL OIL
- (3) Example: Calcium chloride solution, Methanol, Glycol solution, Dowtherm J, Syltherm

Heat transfer fluid for low temperature service

In general they use glycol mixture for low temperature service but in this design guide it is not included.

Heat transfer fluid for vapor / liquid system

Mixtures of alkylated aromatics, diphenyl and diphenyl oxide are used for condensing heat transfer services.

Heat transfer fluid for high temperature service

- (1) Application temperature range is 275~375°C.
- (2) Types of the fluids for high temperature application: Synthetic paraffin, Diaryl alkanes, Poly-phenyl derivatives, Aryl ether, Di-methyl siloxane polymer
- (3) Inorganic compounds also are used and are non flammable, thermally stable, non volatile but corrosive; sodium nitrate(질산나트륨), sodium nitrite(아질산나트륨), potassium nitrite(아질산칼륨)

Inorganic salt mixtures are also an option. Process temperatures much higher than 350 °C are difficult to achieve with organic fluids but can be handled easily with molten salts, notably the eutectic mixture of 53% KNO₃, 40% NaNO₂ and 7% NaNO₃. This can be used at temperatures up to 500 °C and has a very low operating vapor pressure, although it has a disadvantage that it freezes at 143 °C. The only way to obtain this is by using a water dilution system; adding water to make a 60% solution will lower the freezing point to 20 °C. Careful heating allows the water to boil off so that it can be removed by a condenser, and when the system is cooled down the water is sprayed back into the storage tank. Although this salt mixture is an oxidizing agent and will support combustion, it is not flammable like organic fluids. In addition, its very low vapor pressure and low toxicity can be advantageous.

These fluids are thermally stable in correctly designed fluid heating systems. The efficiency of the plant is retained as the fluids are non-corrosive – hence heat transfer surfaces remain clean without the need for any treatment of the fluid. Nor annual shutdown is required for insurance inspection, and the problems associated with freezing of the system on shutdown during cold weather are eliminated. The fluids, however, do slowly degrade.

3. COMMERCIAL HOT OIL DATA

3.1 Commercial hot oil evaluation

(동해-1가스 project 적용실례)

항목	광유계열	합성유계열	실리콘유계열
제품명 (업체명)	Thermia B (Shell) 히트트랜스퍼P-68 (LG-Caltex) 다후니씨믹오일68 (S-Oil)	Dowtherm RP (Dow) Therminol 66 (Monsanto)	Syltherm800 (Dow)
최적운전온도	15~320 °C	0~350 °C	-40~400 °C
피막온도한계	340 °C	375 °C	?
300 oC이상 연속운전시 안정운전기간	수개월	5~10년	10년
동점도	적정	우수	우수
열전도도	우수	적정	미흡
비열	적정	적정	미흡
가격	저가	중가	고가
선정		O	
선정주요사유	고온에서 연속운전이 불안하다고 판단되며, 열분해등으로 degradation 예상	가격대 성능비가 우수하며 고온에서도 안정한 운전이 가능하다고 판단됨	가장 안전하고 안정하나, 열전도도 및 비열면에서 기본 설계 사항에 크게 못 미침 (70% 내외) 타 선택사항에 비해 매우 고가임

3.2 Typical hot oil selection

(Vapor pressure shown on this table is at the maximum temperature)

Hot Oil	Maker	Base	Temp(°C)		Vap. Pres kg/cm 2A	Pour Point (°C)	Flash Point (°C)	Ignition Point (°C)
			Min	Max				
Chemtherm 550	Coastal	Paraffin Oil	40	320	0.14	-10	200	350
Dowtherm G	Dow	Aryl ether	-5	370	3.0	-35	140	580
Dowtherm HT	Dow	Hydro Poly-phenyl	-5	340	1.1	-25	180	350
Dowtherm LF	Dow	Alkyl Aromatics	-40	340	3.3	-	110	470
Hitec	Coastal	Nitrate, Nitrite	260	530	-	140	-	-
Mobiltherm 603	Mobil	Paraffin Oil	40	320	-	-5	170	350
Multitherm IG-2	Multitherm	Paraffin Oil	65	320	0.07	-30	230	370
Multitherm PG-1	Multitherm	Paraffin Oil	65	280	1.1	-40	170	530
Syltherm 800	Dow	알킬실록산 폴리머	-30	400	14.0	-40	180	380
Syltherm XLT	Dow	폴리디메틸 실록산	-70	260	5.6	-100	55	350
Syntrol 350	Exxon	Diaryl Alkane	-30	370	1.3	-35	190	410
Thermalane 550	Coastal	Synthetic Paraffin	-30	280	0.07	-40	220	380
Thermalane 600	Coastal	Synthetic Paraffin	-30	300	0.07	-70	240	380
Thermalane 800	Coastal	Synthetic Paraffin	-30	330	1.5	-75	230	380
Thermalane FG-1	Coastal	Paraffin Oil	40	280	0.6	-40	170	530
Thermalane L	Coastal	Synthetic Paraffin	-45	260	0.9	-85	165	330
Therminol 55		Alkyl Aromatics	-30	320	0.5	-40	180	360
Therminol 59	Solutia	Alkyl Aromatics	-45	320	1.1	-70	150	410

Hot Oil	Maker	Base	Temp(°C)		Vap. Pres kg/cm 2A	Pour Point (°C)	Flash Point (°C)	Ignition Point (°C)
			Min	Max				
Therminol 60	Solutia	Alkyl Poly-phenyl	-45	320	1.6	-70	155	450
Therminol 66	Solutia	Hydro Poly-phenyl	-10	340	1.1	-25	180	370
Therminol 75	Solutia	Alkyl Poly-phenyl	70	400	1.3	50	200	540
Vapor / Liquid System Purpose								
Dowtherm A	Dow	Diphenyl-diphenyl oxide	40	400	10.7	10	120	620
Dowtherm J	Dow	Alkyl Aromatics	-70	320	12.3	-75	55	420
Thermex	Coastal	Diphenyl-diphenyl oxide	40	400	11.0	10	120	640
Therminol Lt	Solutia	Alkyl Aromatics	-70	320	14.5	-75	55	430
Therminol VP-1	Solutia	Diphenyl-diphenyl oxide	-70	400	11.0	10	120	620

3.3 Detailed commercial hot oil data (refer to attachment)

Name	THERMINOL 66	DOWTHERM A	DYNALENE SF
Manufacturer	SOLUTIA	DOW	DYNALENE
Property			
Appearance	Clear, Pale Yellow Liquid		Clear, Light Brown Oily Liquid
Composition	Modified Terphenyl	Diphenyl Oxide/ Biphenyl Blend	Alkylated Aromatics
Flash Point (°C)	min. 184	113	180
Fire Point (°C)	212		210
Auto. Ignition Point (°C)	374	615	330
Min. Pumping Temp. (°C)	-3~11	12	-10
Boiling Range (°C)	348 ~ 392	257~400	> 330
Viscosity (cP)	1320 @ 0°C 3.6 @ 100°C 0.86 @ 200°C 0.25 @ 325°C	5.0@ 15°C 0.13@ 400°C	160 @ 0°C 2.8 @ 100°C 0.66 @ 200°C 0.26 @ 300°C
Density (kg/m3)	1021 @ 0°C 955 @ 100°C 885 @ 200°C 788 @ 325°C	1062.3@ 15°C 679.5@ 400°C	890 @ 0°C 823 @ 100°C 755 @ 200°C 688 @ 300°C
Heat Capacity (kJ/kg-K)	1.49 @ 0°C 1.84 @ 100°C 2.19 @ 200°C 2.67 @ 325°C	1.556@ 15°C 2.702@ 400°C	1.89 @ 0°C 2.26 @ 100°C 2.62 @ 200°C 2.99 @ 300°C
Thermal Conductivity (W/m-K)	0.118 @ 0°C 0.114 @ 100°C 0.106 @ 200°C 0.091 @ 325°C	0.139@ 15°C 0.078@ 400°C	0.136 @ 0°C 0.129 @ 100°C 0.121 @ 200°C 0.112 @ 300°C
Vapor Pressure (kPa)	0.048 @ 100°C 2.2 @ 200°C 52 @ 325°C	 1060 @ 400°C	0.138 @ 160°C 0.897 @ 200°C 23.52 @ 325°C
Other Products	THERMINOL-LT/D-12/XP/55/59/72/75/VP-1	DOWTHEM-G/J/HT/Q/RP/MX/T/800/XLT/HF	DYNALENE-600/HT
Home Page Address	www.therminol.com	www.dowtherm.com	www.dynalene.com

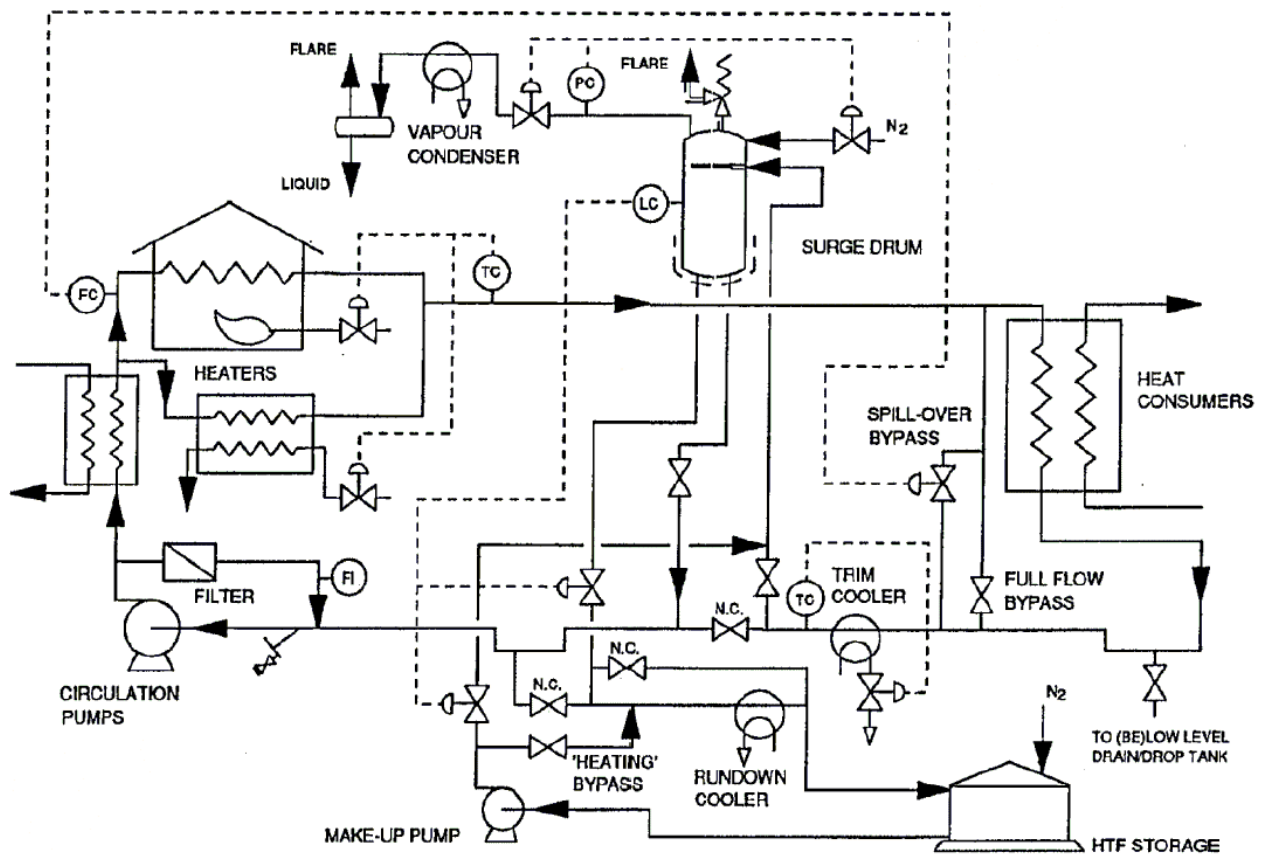
Name	THERMOIL 100	MULTITHERM FF-1	PARATHERM-CR
Manufacturer	IMPERIAL OIL	MULTITHERM	PARATHERM
Property			
Appearance			Clear, Brine Water White
Composition			Synthetic Hydrocarbon
Flash Point (°C)	252		43
Fire Point (°C)			
Auto. Ignition Point (°C)			221
Min. Pumping Temp. (°C)	5		
Boiling Range (°C)	349		142
Viscosity (cP)	86.3 @ 38°C 8.9 @ 100°C	101.2 @ 10°C 3.53 @ 93°C 0.73 @ 204°C 0.46 @ 260°C	
Density (kg/m3)	866.5 @ 38°C 822.1 @ 100°C 749.4 @ 200°C 664.6 @ 316°C	914 @ 10°C 861 @ 93°C 789 @ 204°C 752 @ 260°C	850 @ 0°C 800 @ 100°C 700 @ 150°C 650 @ 200°C
Heat Capacity (kJ/kg-K)	1.93 @ 38°C 2.15 @ 100°C 2.52 @ 200°C 2.93 @ 316°C	1.76 @ 10°C 2.14 @ 93°C 2.64 @ 204°C 2.81 @ 260°C	1.85 @ 0°C 2.23 @ 100°C 2.44 @ 150°C 2.65 @ 200°C
Thermal Conductivity (W/m-K)	0.13 @ 38°C 0.126 @ 100°C 0.118 @ 200°C 0.11 @ 316°C	0.1284 @ 10°C 0.1223 @ 93°C 0.1142 @ 204°C 0.1104 @ 260°C	0.142 @ 0°C 0.134 @ 100°C 0.130 @ 150°C 0.126 @ 200°C
Vapor Pressure (kPa)	0.074 @ 200°C 1.04 @ 260°C 5.21 @ 316°C	0.0004 @ 93°C 0.092 @ 204°C 0.59 @ 260°C	126.8 @ 204°C
Other Products	THERMOIL- 32/46 ESSO THERM Light/N 100	MULTITHERM- PG-1/IG- 1/IG-4/ OG-1/503/ULT-170/LT- 112/WB	PARATHERM- HE/LR/MR/NF/OR
Home Page Address	www.imperialoil.com	www.multitherm.com	www.paratherm.com

Name	Thermia Oil B	XCEL THERM 550	MOBIL THERM 600
Manufacturer	SHELL	RADCO INDUSTRY	MOBIL
Property			
Appearance		Pale Yellow Liquid	
Composition			
Flash Point (°C)	220 ~ 232	165	230
Fire Point (°C)	255	193	
Auto. Ignition Point (°C)	375	338	
Min. Pumping Temp. (°C)		-23	
Boiling Range (°C)	> 355	293 ~ 446	
Viscosity (cP)	199 @ 0°C 4.04 @ 100°C 1.04 @ 200°C 0.43 @ 300°C		26 @ 40°C 4.6 @ 100°C
Density (kg/m ³)	868 @ 15°C	892 @ 25°C	857 @ 15°C
Heat Capacity (kJ/kg-K)			
Thermal Conductivity (W/m-K)			
Vapor Pressure (kPa)			
Other Products		XCEL THERM-445/500/550	
Home Page Address	www.shell.com	www.radcoind.com	www.mobil.com

4. HOT OIL SYSTEM DESIGN GUIDE

Typical hot oil system with full option is composed of:

- Fired heater or Waste Heat Recovery Unit
- Circulation pumps
- Makeup pumps
- Expansion Drum (Surge drum)
- Vapor condenser with separator
- Trim cooler
- Rundown cooler
- Storage tank
- Filters
- Drain tank and pump (not shown in the figure below)
- Hot oil temperature control, N2 blanket with pressure control



4.1 Heater

The heat energy producer may be a furnace or a (fired or unfired) waste heat recovery unit (WHRU), linked to a gas turbine or other hot flue-gas producers. The heater design shall ensure that the HTF will not be subjected to temperatures in excess of the maximum allowable film temperature.

To provide sufficient operational flexibility and, in the case of organic fluids, allow for an acceptable degree of fluid ageing, the location of maximum HTF film temperature and the peak heat flux should not coincide.

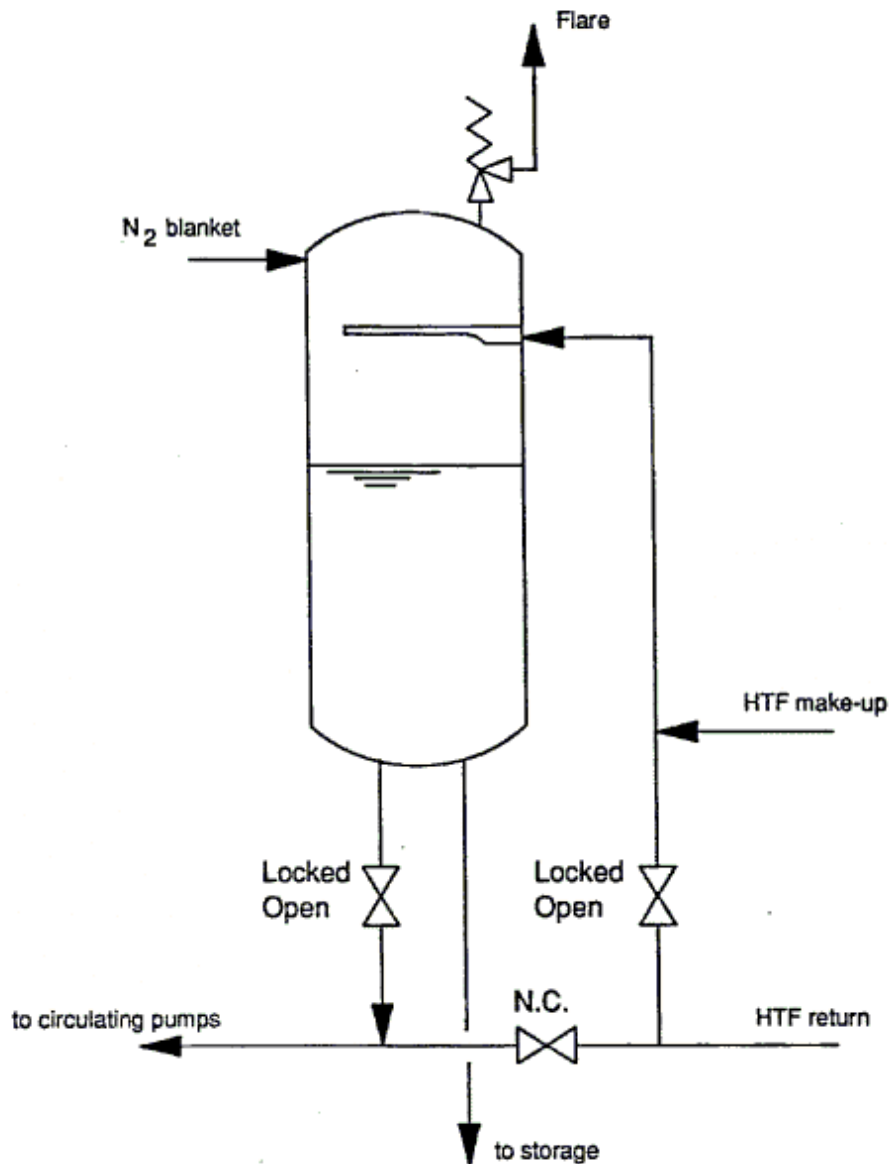
The heater design shall comply with the relevant sections of the followings:

DEM-9422 Fired Heater

API std.560 Fired heaters for general refinery service

4.2 Expansion Drum (Surge drum)

The expansion drum allows for the thermal expansion of the HTF, the venting of low boiling components generated in the HTF ageing process, and is also used to minimize the consequences of upsets in the HTF system operation, Where applicable the design shall take into account the following:



- Provision of adequate volume to accommodate the fluid thermal expansion when heated from ambient to normal working temperature;
- Provision of adequate Net Positive Suction Head (NPSH) of the HTF circulating pumps;

- Prevention of HTF spillover into the flare system in case of a sudden vapor release into the circuit due, for example, to a tube rupture inside heat-transfer equipment operating at a process pressure above that of the HTF circuit;
- The displacement of HTF as a result of the steaming out of a heater coil (following a tube burst);
- The presence of residual quantities of water in the circuit during startup;
- Prevention of loss of HTF circulation in the case of a sudden loss of fluid due to e.g. a tube rupture inside heat transfer equipment operating at process pressures below that of HTF circuit;
- Provision of sufficient HTF inventory to allow the filling of individual heat consumers during pre-commissioning after shutdown for maintenance.

When a separate HTF storage tank with standby facilities for HTF make-up/draw off is provided, it will tank account of some of the volume requirements listed above, thereby allowing a smaller size expansion drum.

4.2.1 Expansion drum location and arrangement

The expansion drum shall be located upstream of the HTF circulation pumps. The drum should be located at an elevation such that the normal operating HTF level in the drum will be located above the elevation of the highest component in the HTF-system. This elevated arrangement will ensure a positive venting capability for the circuit and facilitate the provision of sufficient NPSH for the pumps.

If this requirement would be difficult to accommodate, a lower elevation may be selected but provisions shall be made to prevent vapor being locked in the higher parts of the circuit and to evacuate such a vapor lock if it occurs. The drum shall be designed for full flow of the HTF through the vessel (double-leg design, see above figure). The application of a simple expansion vessel layout (single-leg design) requires approval.

The expansion drum shall be provided with a dry inert gas blanket to prevent the HTF from coming into contact with oxygen or picking up moisture. Oxygen will accelerate fluid degradation; some HTFs may produce acidic compounds in the presence of oxygen, such reactions being accelerated by the fluid return temperature which will be significantly above ambient conditions. Moisture ingress may lead to sudden pressure surges in the circuit upon vaporization of the water; moisture picked up by silicone polymer based HTFs will deactivate the fluid's stabilizing additive, whereby deposits will be formed and fluid degradation will accelerate.

The preferred inert gas is dry nitrogen, but in some cases other dry, oxygen-free gases (CO₂ or sweet fuel gas) may be used; the HTF manufacturer shall be contacted for confirmation of the compatibility of such blanket gases with the selected fluid. The inert-gas supply shall be provided with a split range controller. This controller can import inert gas (N₂) or export to flare. To avoid unnecessary consumption of inert gas, the controller output shall have a gap between import and export. A non-return valve shall be installed in the inert gas supply line to prevent backflow in case of overfilling of the expansion drum.

The drum vent line shall be provided with a back pressure regulator set sufficiently above the HTF working pressure level to minimize venting of low-boiling compounds (low boilers) and consequential loss of HTF inventory. The back pressure regulator setting may be increased further to satisfy the MPSH requirements of the circulation pumps, but then the system design shall account for the increased working pressure. In cases where regular venting of vapors is unavoidable, a vapor cooler condenser should be installed downstream of the regulator to recover the low boiling compounds. This reduces emissions and also allows indication of the amount of low boilers being produced, thereby providing an indication of the progress of HTF degradation. The recovered low boiling compounds shall not be returned to the HTF system, but shall be disposed of properly. In general the vent line shall be routed to flare; only in cases where the vapors meet the criteria of being non-toxic, non-flammable and odorless, may venting to a safe location be considered.

The vessel shall be provided with safety relief facilities capable of protecting the complete circuit against over pressurization, including that caused by excessive formation of low boiling point compounds resulting from degradation of the HTF or inadvertent vapor releases into the system due to tube ruptures inside equipment that operate with elevated pressure at the process side. To be able to stream purge out the furnace coils, the sizing of the surge drum relief valve shall also be capable of relieving the flow of purging medium (e.g. steam, nitrogen) which is equivalent to a vapor velocity in the furnace coils of 15 m/s. If necessary the purge flow can be limited by installing a restriction orifice in the common supply line. The relief line shall be routed to flare.

Consideration shall be given to provide tracing to the inert gas supply, vent and relief lines up to the relief header to prevent accumulation of any high boiling condensate or crystallizing compounds leading to possible line obstruction.

In climates where the ambient temperature can fall below the HTF minimum application temperature, the expansion drum should be provided with a heating coil to improve the suction conditions from the circulation pumps

during startup. To prevent foaming/overflow of HTF in the event of a coil leak, electrical heating internally or externally is preferred.

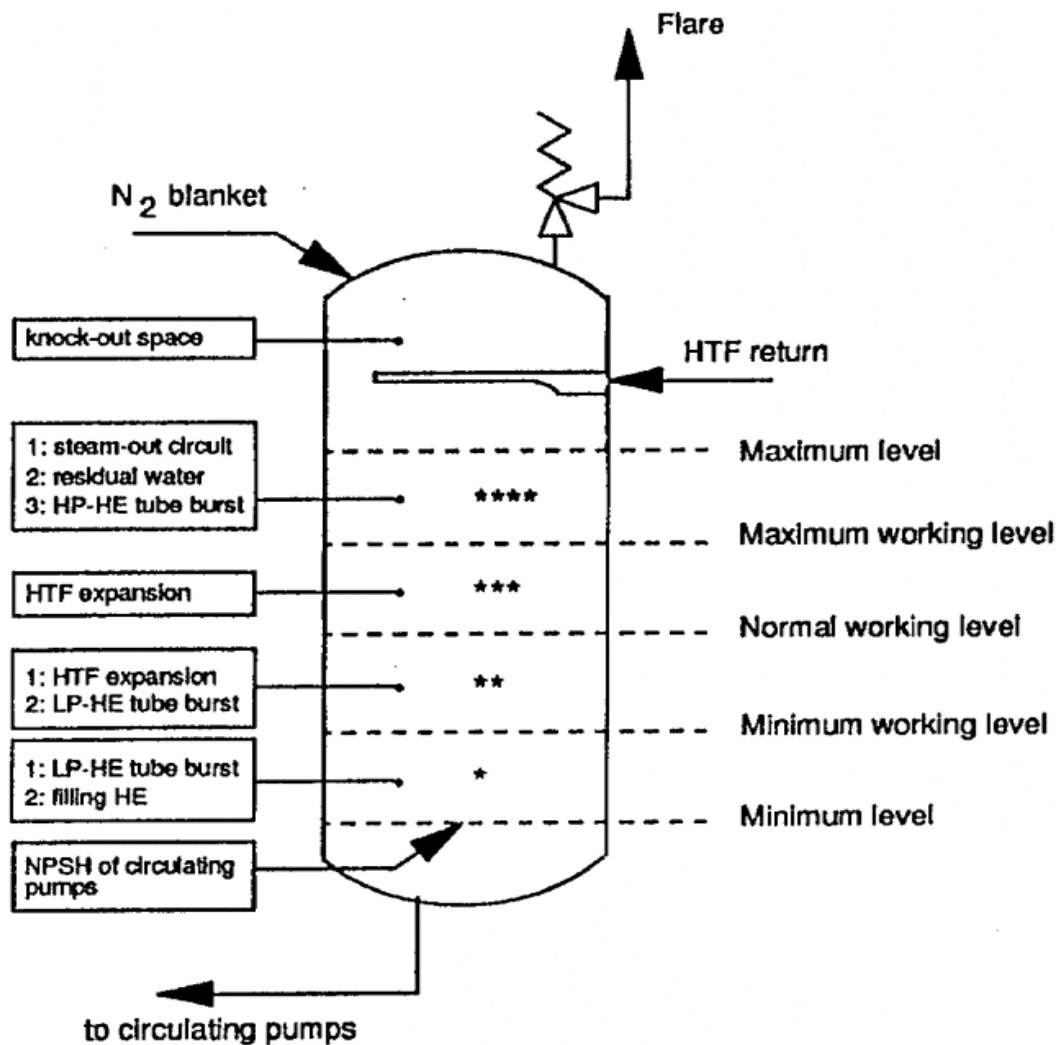
The vessel shall be designed for the upper design temperature and pressure of the HTF system.

4.2.2 Expansion drum sizing

This section discussed the sizing criteria for typical HTF expansion drums. As the sizing depends upon the fluid properties as well as its inventory inside the circuit, an expansion drum design based upon estimated line and equipment sizing and preliminary plot plans shall be adjusted in accordance with the finalized project design situation. It is the responsibility of the designer to review and, if necessary, revise the vessel design when line sizes, plot plans and piping layouts are finalized.

Care shall be taken to base the relief calculations for the expansion drum sizing on the working pressure differential between the HTF and consumer process sides. If the design pressure of the HTF side of the system is lower than the process sides, process fluid will enter the HTF side in the case of a tube leak.

A distinction is made between systems that are provided with stand-by HTF makeup / draw-off facilities and those without. Next figure shows the levels distinguished in a typical expansion vessel arrangement.



4.2.2.1 Systems without stand-by HTF make-up / draw-off facilities

In these systems the expansion drum has the combined functionality of an expansion, knock-out and storage vessel, capable of handling the fluid inventory during normal operation and foreseeable upsets.

The vessel diameter shall be calculated and the maximum level set to prevent entrainment of HTF liquid into the flare line in case of a sudden vapor ingress into the system caused either by a tube rupture inside heat transfer equipment or by the streaming out of furnace coils.

The minimum level setting shall be established to ensure the provision of adequate NPSH for the HTF circulation pumps taking into account the fluid viscosity at minimum temperature (start up conditions).

The volume between the minimum level and the minimum working level shall be at least the larger of the following:

- * The volume of HTF lost in 15 minutes via a ruptured tube in a heat exchanger operating with a process pressure lower than the HTF system pressure;
- * The volume required to allow the filling of an individual HTF consumer after a maintenance shutdown assuming interruption of make up for any reason.

The volume between the minimum working level and the normal working level shall be at least the larger of the following:

- ** The volume increase of the total HTF inventory when the temperature is raised from operational to normal working level;
- ** The volume of HTF lost via a ruptured tube in 15 minutes in a heat consumer operating with a process pressure below the HTF system pressure.

The volume between the normal working level and the maximum working level shall be at least:

- *** The volume increase of the total HTF inventory when the temperature is raised from normal to maximum working level.

In case a drop tank is included in the circuit, the volume between the minimum working and maximum working levels shall be equal to the maximum volume of HTF supplied to the system in 15 minutes. As the drop tank will be atmospheric, a rundown cooler shall be installed to avoid to hot fluid entering the tank (See 4.4 HTF storage also).

The volume between maximum working level and maximum level shall be at least the larger of the following:

- **** Volume of HTF displaced if the furnace coils are steamed out via the full flow bypass of the spill over control valve;
- **** Volume of HTF displaced from any consumer (including associated piping) in case residual quantities of water are inadvertently present at start up the system;
- **** The volume of HTF displaced from a heat consumer and downstream piping as the result of a tube rupture in a consumer operating with a process pressure in excess of the HTF system pressure.

4.2.2.2. Systems with stand-by HTF make-up/draw-off facilities

In these systems a separate HTF (operational) storage is provided, linked to the expansion vessel by means of a level-controlled supply/spill-back piping arrangement (as shown in the scheme of Fig. 1). These facilities provide for a smaller size surge vessel.

The diameter and the minimum/maximum level settings shall be subject to the same criteria as for systems without continuous make-up facilities (see 4.2.2.1. second and third paragraphs).

- * The volume between the minimum level and the minimum working level shall be equal to the volume of HTF lost in 15 minutes via a tube rupture in a heat consumer operating with a process pressure below the HTF system pressure.
- **/** The volume between the minimum working and maximum working levels shall be equal to the maximum volume of HTF supplied to the system in 15 minutes via the make-up line.

The volume between maximum working level and maximum level shall be at least the larger of the following:

- **** The volume of HTF displaced from any consumer (including associated piping) in case residual quantities of water are inadvertently present at start-up of the system;
- **** The volume of HTF displaced from a heat consumer and downstream piping as the result of a tube rupture in a consumer operating with a process pressure in excess of the HTF pressure.

4.3 Circuit

All low points in the circuit shall be supplied with drain connections to enable residual water to be drained prior to commissioning of the system. Facilities for blowing out the circuit with dry hot air or, preferably, dry nitrogen shall be provided to ensure a thorough system dry-out. The latter is particularly important for silicone HTF systems.

Heat consumer equipment that may need to be evacuated (e.g. for temporary decommissioning) whilst the circuit is kept in operation shall be provided with dedicated drainage facilities enabling the HTF to be run down to the storage or drop tank via the rundown cooler.

For systems with heaters arranged in parallel, sampling facilities shall be provided to allow evaluation of HTF degradation in the parallel loops.

For systems with heat consumers operating at pressures above the HTF system pressure, measures shall be taken to prevent over-pressurization of the HTF system as the result of a tube rupture inside the heat-consumer equipment.

As the application of a high supply temperature leads to smaller size heat-consumer equipment, it is expected that HTF system designs will be driven to the application of a supply temperature close to the MABT of the HTF. Particularly in the case where the selection of the HTF would provide only a small temperature approach between the HTF and the process fluid, allowance shall be made for the heat loss over the transfer line from the heater to the heat consumers, causing the HTF supply temperature to fall below the heater exit temperature. Failure to do so will result in either the heat-consumer performance falling below expectations, or the overheating of the HTF, with an ensuing increase in the degradation rate.

4.3.1 Piping

The system shall be designed for a total flow of 110% of the cumulative flows through the consumers.

The spill-over control valve shall be designed for a maximum flow of 30% to accommodate a sudden closure of the consumers. The valve in the (full flow) bypass shall be designed for a flow of 100% for start-up purposes.

To minimize pressure drop over the distribution system, HTF flow velocities in the circuit piping should not exceed 2 m/s.

4.3.2 Insulation

Because of their low viscosities at operating temperatures, most HTFs have a tendency to penetrate joints and seals, resulting in small leaks that can lead to accumulation of fluid inside the insulation at pipe joints. Insulation materials such as magnesia, silicate-bonded asbestos or calcium silicate when saturated by organic HTFs may promote a slow oxidation reaction at temperatures above 250-260°C.

The large internal surface area, poor heat-dissipation conditions and the possible catalytic activity of the insulation material may cause significant temperature build-up within the insulation mass. Such slow combustion may progress undetected but may lead to sudden fires when the cladding is damaged, or opened for maintenance. Non-absorbent (closed cell) insulation (e.g. cellular glass or foam-glass) that will not soak up the fluid shall therefore be used at potential fluid 'creepage' locations (instrument connection, valve stems, flanges and joints).

4.3.3 Auxiliaries

The circulation pump suction line shall be provided with a wire-mesh strainer during system start-up to prevent millscale, weld spatter or other construction debris from entering the pumps. The fine mesh should be removed as soon as these foreign materials have been removed from the circuit, to avoid unforeseen obstruction of the suction line.

In systems with organic type HTFs operating close to the MABT, installation of permanent filters shall be considered. As the fouling of such filters when installed in the main suction line could adversely influence the NPSH of the circulation pumps, they should be installed in a bypass over these pumps, allowing the filtering out of a small amount of fluid that is returned to the pump suction (refer Fig. 1). The provision of a flow indicator in this bypass allows monitoring of the onset of fouling.

4.4 HTF storage

The HTF storage tank shall be capable of containing the full inventory of the HTF circuit. Additional capacity shall be included to hold the fluid volume for making up the loss due to ageing (10% of the inventory) and the amount of fluid lost in 15 minutes as a result of a tube rupture inside heat-exchange equipment.

The minimum level shall be set to ensure sufficient NPSH for the make-up pump, taking into account the viscosity at the minimum fluid storage temperature. In climates where the ambient temperature can fall below the HTF minimum application temperature, the tank shall be supplied with a heating coil to improve the suction conditions for the make-up pump. To avoid moisture ingress, electric heating is preferred and the storage tank should be supplied with a dry inert gas blanket.

The provision of stand-by make-up/draw-off facilities not only results in a smaller size expansion drum, but also limits the amount of HTF being subjected to elevated temperature levels, i.e. minimization of fluid ageing. In the latter case, the operation of the make-up pump and the rundown control valve shall be controlled by a level controller on the expansion drum.

The storage tank now also functions as a drop-tank and a rundown cooler shall be provided to prevent too hot fluid entering the tank. In case a rundown cooler is installed, it may be given a reverse function (heating the HTF inventory in the storage tank) by the provision of a simple "heating bypass". This arrangement obviates the need to install a heating coil inside the tank.

The function of the rundown cooler can also be taken up by a sufficiently large inventory of cold HTF inside the drop tank. Provided this "cold heel" and the drop-tank ullage are sized adequately, this option will ensure a fail-safe and fast disposal route for the full system inventory in a case of an emergency. It will also obviate the requirement for a large (and expensive) rundown cooler, which normally will have to be used only infrequently and therefore might present operational problems when its proper functioning is essential.

4.5 Trim Cooler, Rundown Cooler

To facilitate the start-up and increase the flexibility of the system, a trim cooler should be installed in the circuit, capable of replacing the heat duty of the biggest consumer or the minimum heater duty whichever is the larger.

A rundown cooler is required in order to allow hot HTF to be run down from the circuit in case a heat consumer is taken out of service and the HTF liberated by emptying the equipment cannot be contained in the expansion drum. To mitigate adverse effects of moisture ingress into the expansion drum, the make-up supply shall be fed not directly into the expansion drum but to the HTF return line close to the expansion drum instead.

To prevent the formation of scale inside the tubes, the cooling medium for the vapor condenser, trim cooler and rundown cooler shall not be cooling water. For these cooling services properly treated water (e.g. condensate or boiler feed water) should be used, or alternatively, air cooling may be applied.

4.6 Heat Consumer

When designed and operated properly, HTF systems can be considered a clean(non-fouling) service so that U-tube type heat exchangers can be applied on the heat consumer side when the HTF flows inside the tubes. This saves in cost (U-tube types being roughly 30% less expensive than floating-head type exchangers), but also significantly reduces the risk of leakage and contamination of the HTF of process fluid.

To enable proper engineering design of the heat exchangers, the requisition sheet shall clearly mention the type of HTF of the trade name of the fluid to be used. For the design specification of HTF systems a fouling resistance of $0.00017 \text{ m}^2 \text{ K/W}$ shall be used.

For systems operating at moderate temperature levels(below 275°C) the application of the (simple) hot-oil type fluid may still be considered. Being derived as straight-run mineral oil distillates, such hot oils will be cheaper and easier to source than the comparable synthetic organic HTFs. However, unlike the latter HTFs, the hot-oil types have not been developed to sustain long-term operation at specified temperature levels and have significantly lower temperature stability. Hot oil systems therefore are susceptible to fouling even when operating at moderate temperatures.

As a consequence, the hot-oil system design shall take into account the appropriate fouling resistances. Equipment in hot-oil service shall have provisions to enable proper cleaning of the heat-transfer surfaces; this would mean e.g. the application of floating-head type heat exchangers.

For applications where leakage of HTF into process fluid could lead to hazardous situations(e.g. in the case of HTF air pre-heaters), the equipment design pressure shall be at least twice the highest pressure that can occur in the system(e.g. pump shut-off pressure or relief valve set pressure), and the use of flanged connection shall be minimized.

4.7 Pumps

Circulation pumps provide with different drives. Depending on local conditions (e.g. energy balance or reliability requirements) both pumps can be either electric motor or turbine driven.

The pumps shall be designed for the maximum furnace outlet temperature at design conditions.

In case of low HTF pressure, the spare pump shall take over automatically. This shall be indicated in the control room by an alarm and indicating lights.

In case the HTF is operated at or above the auto-ignition temperature, the pump suction valves shall be remotely operated.

4.8 Instrumentation and control

The instrumentation for an HTF system shall be engineered in accordance with the specifications selected.

All instruments shall be able to withstand the maximum HTF pressure and temperature. Special care shall be taken that, when heat-traced lines can be blocked in, the instruments on these lines are not damaged due to excess pressure.

System turn down should enable, with minimum operator intervention, stable operation from the condition of full heat consumption to that of zero heat consumption. The preferred control set-up combines the provision of adequate turn down with the conservation of energy by controlling the flow through the spill-over bypass with a flow controller upstream of the heater.

This controller should prevent the flow in the circuit from falling below the heater minimum coil flow. The maximum return temperature shall be controlled by the trim cooler, which should be sized for at least the minimum heater duty. The maximum return temperature level is fixed by the minimum pass flow, maximum heater outlet temperature and heat input at minimum stop of the burners.

For large systems (> 50 MW thermal duty), coil balancing of the heater outlet temperature should be applied. This standard algorithm shall adjust the coil flows to equalize the coil-outlet temperatures whilst maintaining maximum valve opening for the individual passes.

4.9 Material Selection

Material should be selected base on the following consideration:

- (1) In general, carbon steel is used in most case.
- (2) Aluminum, brass and bronze will not be used.
- (3) Cupper and cupper alloy can be adopted in the place of no air contact.
- (4) Austenite stainless steel will not be used if chlorinated contamination is concerned.

5. OPERATIONAL REQUIREMENTS AND PRECAUTION

Although the physical advantage of hot oil, such as a high thermal stability, a low operating pressure at high temperature, and a low viscosity, make its use as a heat transfer medium highly attractive, there are several points to which attention should be drawn to ensure trouble-free operation.

5.1 Starting the Plant

It should be ascertained that all parts of the plant are correctly assembled, and that all special requirements for venting, safety valves, expansion vessel, etc., have been included. All new equipment should be cleaned and free from loose rust, scale, dirt or pieces of weld metal. Water should be circulated through the system; afterward, pump strainers should be cleaned and the system thoroughly dried out. All pipelines and other parts of the equipment should be pressure tested before use, preferably with hot oil rather than water.

Filling with Hot Oil

Before the initial filling of a plant, it is necessary to ensure that the correct operating level is clearly marked. Hot oil expands on heating and allowance must be made for the expansion of liquid between the filling and operating temperatures.

The hot oil is normally at room temperature when the plant is being charged; if the ambient temperature is below 12°C, the hot oil will require heating in order to liquefy it, and special precautions will be necessary to ensure that subsequent solidification does not take place in the pipelines and other parts of the system during filling. When filling under very cold conditions, it is advisable to warm the plant with hot air, and to fill the heater first.

Circulation of hot oil through the heater and its by-pass is then started and the hot oil is gradually fed to other parts of the system, the addition of liquid hot oil being continued until the plant is filled to the necessary level. If it is necessary to warm the hot oil before filling the plant, particular care should be taken that there are no open flames near the filling point.

Initial Heating

The first heating of a plant, after commissioning or after a prolonged shut down, should be carried out very slowly. Although plants should be provided with a storage and discharge vessel for hot oil in some cases this may not have been included, or the plant may have been incompletely drained, so that some lines are blocked by solid hot oil.

If the presence of solid material is suspected, testing must be extremely cautious and the temperature of the heater should be kept to a minimum until circulation is established.

If gentle heating is not successful in establishing circulation(say 50°C at heater coils), heating should be discontinued and the blockage located and cleared by applying gentle external heat to the affected portion of line. Extreme heat is not required for clearing blockages; raising the room temperature will usually be sufficient to clear lines inside a building, while low-pressure steam is normally adequate for thawing external lines.

Once circulation has been established, heating can be continued slowly up to the operating temperature, all flanges and joints being checked for leaks after every 50°C rise. All vents and the by-pass to the safety valve, if fitted, should be open until all air pockets have been removed from the system.

Plants operating at atmospheric pressure should not be heated to such an extent that hot oil is discharged from the vent pipes or from the condenser. Plants operating under pressure should never be heated beyond the hot oil temperature corresponding to the test pressure of the plant, or in any case higher than 400°C. Most plants operating under pressure are fitted with automatic controls limiting the maximum obtainable.

Removal of Extraneous Water

The presence of extraneous water in a hot oil system can be dangerous, owing to the high vapor pressure of water at temperatures above 100°C. It is therefore recommended that, after a hydraulic test with water, new plant should be thoroughly dried by compressed air before being filled with hot oil. Alternatively, the water can be vaporized and vented to atmosphere before the plant system is brought up to its full working temperature.

5.2 Supervision of Operation

The level of hot oil charge in the system should be checked at regular intervals. Changes in hot oil composition arising from prolonged operation or extraneous causes should be periodically checked. The changes due to polymer formation are best checked by physical measurements of the distillation range, crystallization point or viscosity. Where contamination with process materials is suspected, tests should be made immediately for the chemicals concerned, as most organic chemicals are much more liable to carbonize than hot oil is, and if left in the system will impair heat transfer and may even choke pipelines.

Analysis and Replacement Service

When the polymer content, that is the amount distilling at temperatures above 260°C under atmospheric pressure, is in the range 10 ~ 15%, the hot oil should be replaced. This can be done either by regenerating the degraded material locally or by using the replacement service operated by vendor. It should be noted that it may not be possible to regenerate hot oil that has been contaminated by large quantities of material of low thermal stability, such as greases or tars.

When HTF is decomposed due to thermal degradation, flash point, ignition point and auto-ignition temperatures are lower than its original properties that need to check the following properties.

(1) Viscosity

Viscosity effects fluidity and heat transfer efficient. If it is lower viscosity, than it gives better heat transfer and fluidity but changing viscosity reveals thermal degradation of hot oil. Along with time, viscosity increases in poly-phenyl derivatives and in mineral oils but decreases in synthetic paraffin.

(2) Acid Number

Hydrolysis or oxidation degree can be checked via acid number. Maximum is 4.0mgKOH/g-oil in paraffinic compounds, 1.0 mgKOH/g-oil in poly phenyl compound.

(3) Non acetone soluble

Carbon and solids scale is measured. Maximum is 50mg/ml-oil to avoid erosion.

(4) Water

Water is the source of increasing light volatile compounds and acidic compounds. Maximum allowable should be 2000ppm for synthetic paraffin, 400ppm for aromatic compound.

(5) Light volatile materials

This content shows the degree of thermal degradation. If it exceeds 10%, then flash point and ignition point should be checked.

(6) High boilers (Heavy components)

This content shows the degree of thermal degradation. If it exceeds 10%, then coke will form.

5.3 Maintenance of Plant

Before performing any maintenance work involving the breaking of joints, all the hot oil should be drained from the plant into the storage tank. Where welding is required on a plant item, the part should be thoroughly steamed out to remove traces of hot oil before welding is started. Where the work involved is small, it may be possible to do the operation without danger by filling the section of pipe or plant with nitrogen and maintaining a continuous flow of nitrogen while welding is proceeding. After any maintenance operation the plant should be tested to ensure freedom leaks before being put back into operation.

6. REFERENCE HOT OIL SYSTEMS

Previous experience data for the hot oil system design are presented here. Hot oil system design even if there are some standard design method, actual application is also important reference when they start the design for new system.

6.1 Hot oil system summary of GSP-5 project

Design summary

Hot Oil: PTT사 제품

ITEM NO.	SERVICE	NO. REQ.	TYPE	DESIGN CONDITION			MAT'L CASING/ IMPELLER	Sp.Gr	OPER. TEMP. (Deg'C)
				CAPA. (m3/h)	ΔP (bar)	HEAD (m)			
3508 P01	Hot Oil Transfer Pump	1	CEN	120	3.142	37.0	CS	0.866	15
3508 P02A,B,R	Hot Oil Circulation Pump	2+1	CEN	3549.8	11.636	150.0	CS	0.791	130
3508 P03	Hot Oil Sump Pump	1	VERT	12	0.615	6.3	CS	996.000	28
3508 P04,R	Hot Oil Drainage Pump	2	CEN	36	3.033	37.0	CS	0.836/ 0.701	60/ 270

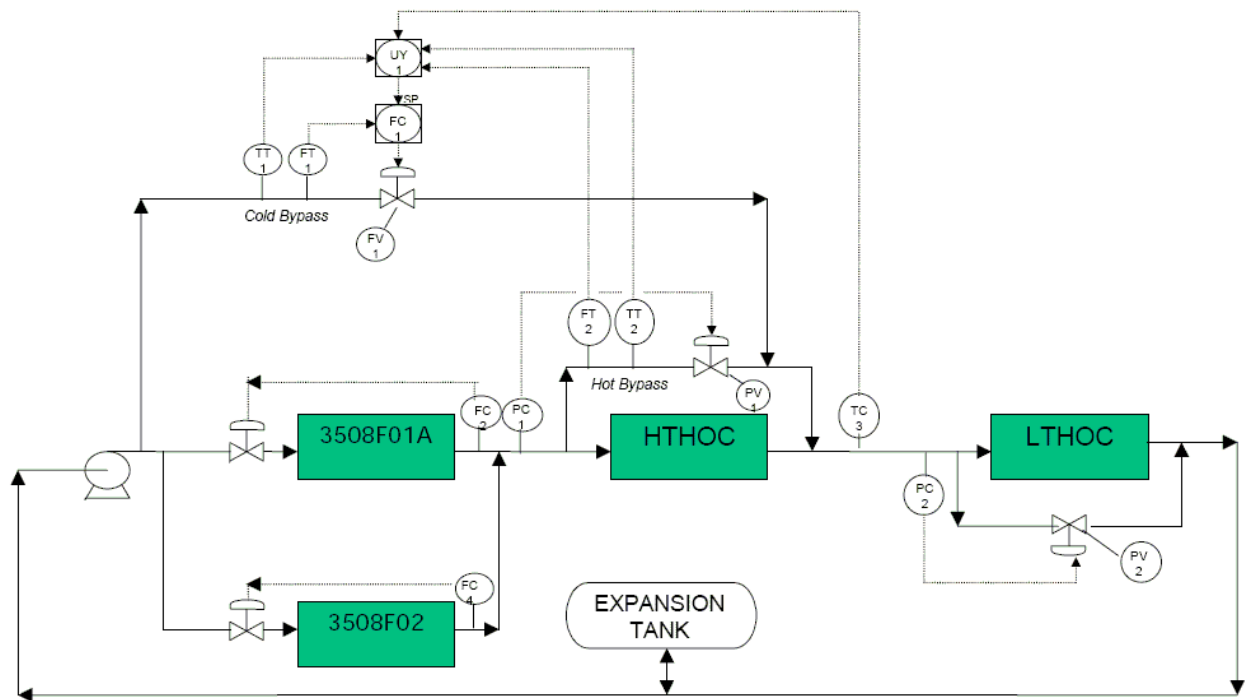
ITEM NO.	SERVICE	NO. REQ.	TYPE	DIMENSION IDxT.L (mm)	CAPACITY	OTHER SPECIFICATION
3508 F01	In-plant Power Generator WHRU	1			32250~86000 kW (Absorbed)	846466kg/h at 130 Deg.C (Max Case) Density 791.1 kg/m3 at 130 Deg.C Temp. In = 130, Temp. Out = 270 deg.C
3508 F02	Sales Gas Compressor Turbine WHRU	1			32250~86000 kW (Absorbed)	846466kg/h at 130 Deg.C(Max Case) Density 791.1 kg/m3 at 130 Deg.C Temp. In = 130, Temp. Out = 270 deg.C

ITEM NO.	SERVICE	NO. REQ.	TYPE	DIMENSION IDxT.L (mm)	MAT'L	DESIGN CONDITION		OPR. CONDITION	
						PRESS. barG	TEMP. Deg'C	PRESS. barG	TEMP. Deg'C
3508 D01	Hot Oil Storage Tank	1	Cone Roof	10100X12000	CS+3.0mm	0.02/-0.006	85	0.0	60
3508 D02	Hot Oil Expansion Tank	1	Horizontal	4750X15000	CS+3.0mm	4	295	0.1	130
3508 D03	Hot Oil Drainage Tank	1	Horizontal	2000X4000	CS+3.0mm	4	295	0.1	270

ITEM NO.	SERVICE	NO. Req'd (Bay)	TYPE	DIMENSION (WxL, mm)	NORMAL HEAT DUTY (MW)	SURFACE AREA (m2)		MAT'L TUBE & TUBESHT	DESIGN COND	
						Bare	Fin		PRESS bar g	TEMP 'C
3508 E01	Hot Oil Trim Air Cooler	1	Forced		18.0x1.05	1,0 45	22,14 7	CS +3.0mm	20.0	295

ITEM NO.	SERVICE	NO. REQ.	TYPE	CAPACITY	DESIGN COND		OPR. COND		OTHER SPECIFICATION
					PRESS barG	TEMP Deg'C	PRESS barG	TEMP Deg'C	
3508S01,R	Hot Oil Recycle Filter	2	Cartridge	355m3/h	20.0	295	12.4	130	Efficiency : 99.5%(>3 Micron:100%) Removed Particle Size : 0.5 ~ 3.0Micron Material: CS (+3.0mmCA)
3508S02,R	Hot Oil Filter	2	Cartridge	36m3/h	8.0	295	1.8	60/270	Efficiency : 99.5%(>3 Micron:100%) Removed Particle Size : 0.5 ~ 3.0Micron Material: CS (+3.0mmCA)
3508S03	Hot Oil Transfer Filter	1	Cartridge	120m3h	6.0	85	1.917	15/60	Efficiency : 99.5%(>3 Micron:100%) Removed Particle Size : 0.5 ~ 3.0Micron Material: CS (+3.0mmCA)

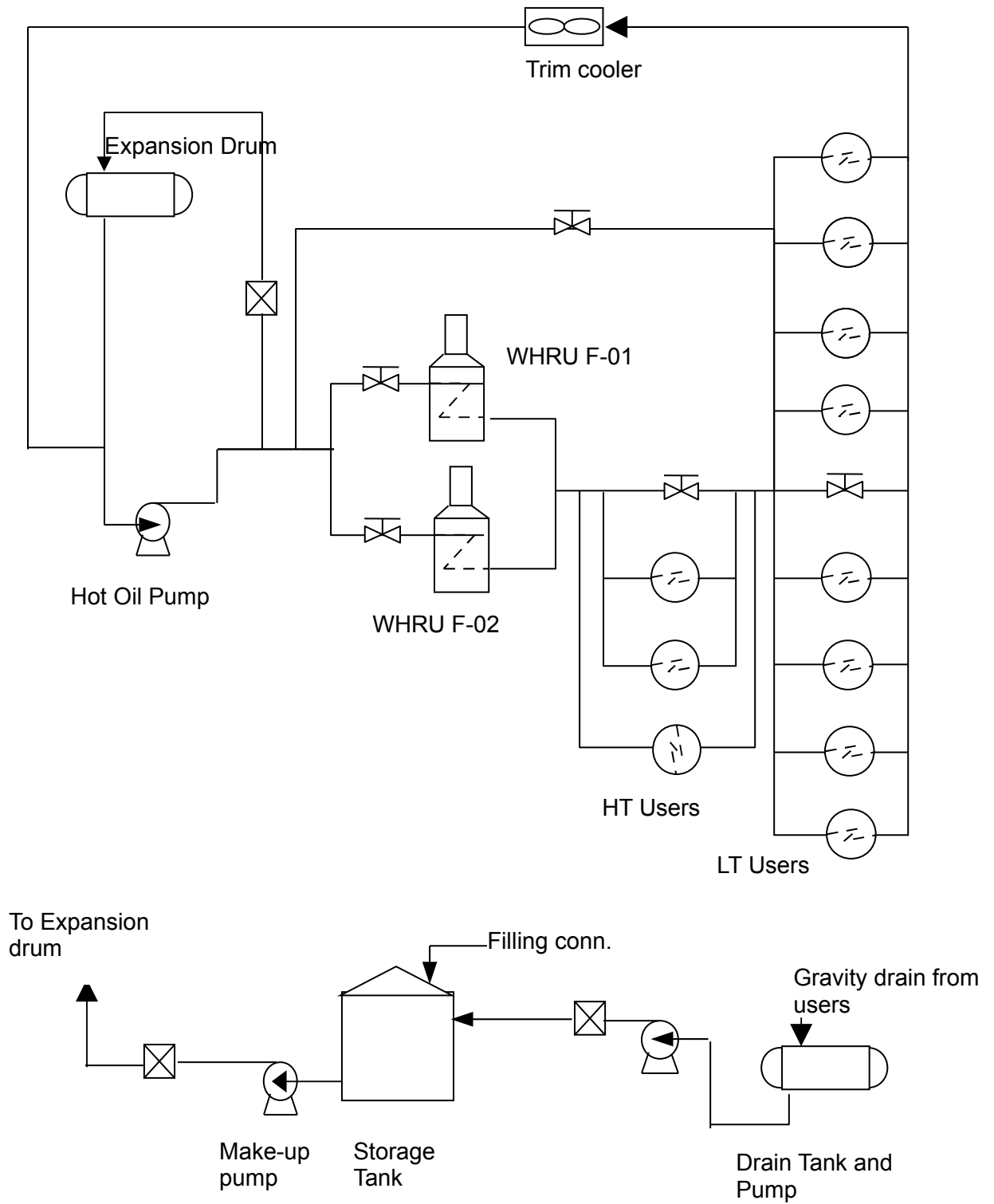
Hot oil control system of GSP-5 project



HTHOC: High Temperature Hot Oil Circuit (270°C supply)

LTHOC: Low temperature Hot Oil Circuit (170°C supply)

Hot oil schematic diagram of GSP-5 project



6.2 Hot oil system summary of Songkhla GSP-1 project

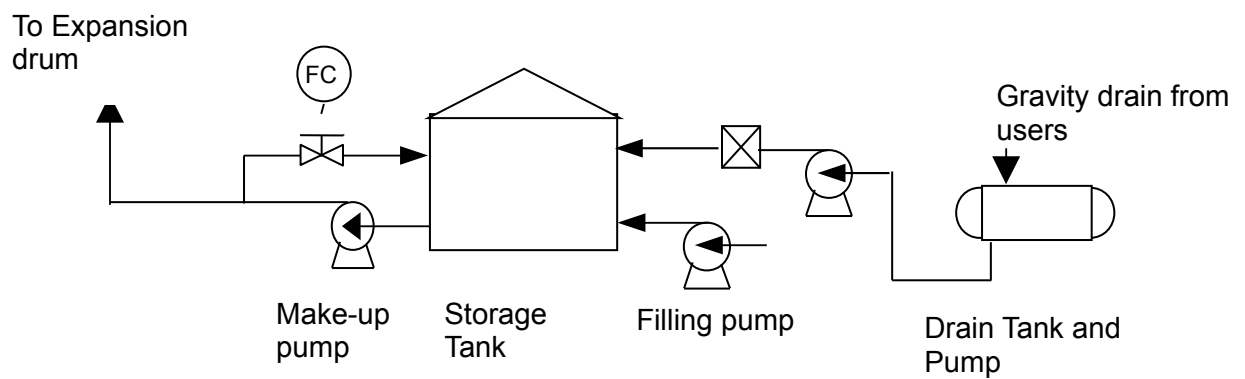
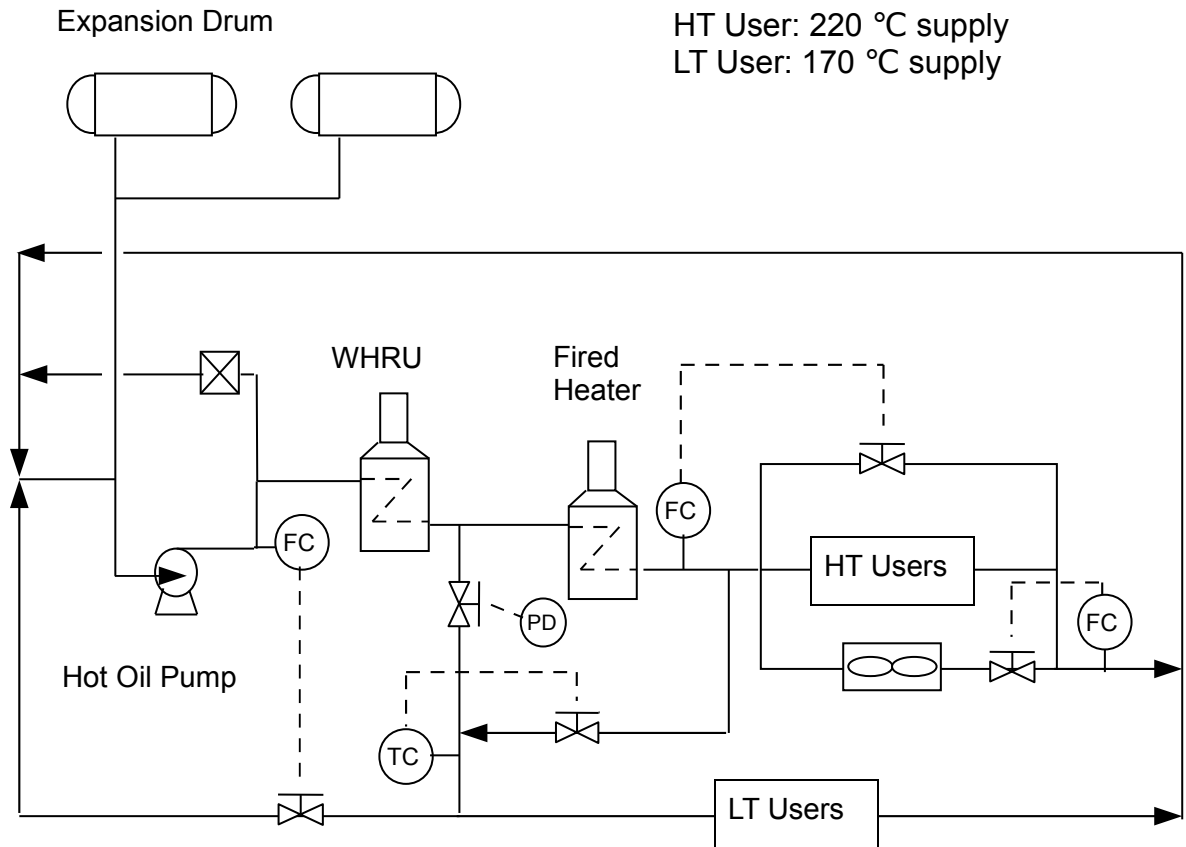
Design summary

Songkhla	
Hot Oil	Shell, Thermia Oil B (Mineral Oil) cf. Thermia B : up to 320 centigrade
Oper. Temp	Low Temp.: 170 oC (-> 140 oC) High Temp.: 220 oC (-> 200 oC)
System Vol	About 550 m3 각 Equipment volume과 Plot plan을 기준으로 Line volume을 계산하고 15% margin을 고려한 값임

Equipment Tag No.	Service Name	Quantity		Type	Duty kW	Elec power kW	Driver	Oper speed rpm	Design condition	
		Oper.	S'by						Press. barg	Temp. max/min°C
1108 -D- 01A/B	Hot Oil Surge Drum	1	1	Hori.	-	-	-	-	3.5	190/19
1108 -D- 02	Hot Oil Sump	1	0	Hori.	-	-	-	-	3.5	240/19
1108 -D- 03	Hot Oil Storage Tank	1	0	Cone	-	-	-	-	0.10/ -0.0025	220/19
1108 -E- 01	Hot oil cooler	1	0	AC	4337	11.0	Motor (2 sets)		21	250/19
1108 -P- 01A/B/C/D	Hot oil circulation pumps	3	1	Cent.	-	400	Motor	2970	21	190/19
1108 -P- 02	Hot oil make up pumps	1	0	Cent.	-	5.5	Motor	2925	4.4	190/19
1108 -P- 03A/B	Hot oil sump pumps	1	1	Cent.	-	5.5	Motor	2950	5.6	240
1108 -P- 04	Hot oil filling pump	1	0	Cent.	-	3.7	Motor	2925	3.8	65
1108 -S- 01	Hot oil filter	1	0	Catr.	-	-	-	-	21	190/19
1108 -S- 02	Hot oil sump filter	1	0	Catr.	-	-	-	-	5.6	240/19
1108 -U- 01—	Hot Oil Heater Package	1	0	-	22530	-	-	-	21 min.	250 min.
1108 -U- 02A-D	Waste heat recovery units	3	1	-	6915	-	-	-	-	-

Equipment Tag No.	Service Name	Operating condition				Dimensions		Rated		Materials
		P. in barg	P. out barg	T. in °C	T.out °C	ID mm	L. mm	Cap. m³/hr	Head m	
1108 D-01A/B	Hot Oil Surge Drum	0.5	-	149	-	3200	8600	-	-	SA516Gr70
1108 D-02	Hot Oil Sump	0.05	-	AMB ~ 220	-	1800	5000	-	-	SA516Gr70
1108 D-03	Hot Oil Storage Tank	0.05	-	AMB ~ 160	-	11000	8500	-	-	SA516Gr70
1108 E-01	Hot oil cooler	4.1	3.6	220	200	-	-	-	-	Header- SA516Gr60 Tube- SA179
1108 P-01A/B/C/D	Hot oil circulation pumps	1.84	14.7	147	-	-	-	781.2	168	API610 Class S-6
1108 P-02	Hot oil make up pumps	0	2.9	AMB	-	-	-	10.0	34.4	API610 Class S-6
1108 P-03A/B	Hot oil sump pumps	-0.3	1.43	AMB ~160	-	-	-	20.0	22.5	API610 Class S-1
1108 P-04	Hot oil filling pump	-0.1	2.5	AMB	-	-	-	6.0	30.9	API610 Class S-6
1108 S-01	Hot oil filter	3	-	147	-	592	1450	-	-	SA516Gr70
1108 S-02	Hot oil sump filter	3	-	220	-	547	1350	-	-	SA516Gr70
1108 U-01—	Hot Oil Heater Package	11.5	10	162 ~ 167	220	-	-	-	-	Header:CS T:SA106Gr B
1108 U-02A-D	Waste heat recovery units	11.1	10.1	149	167	-	-	-	-	By Vendor

Hot oil schematic diagram of songkhla GSP-1 Project



6.3 Hot oil system summary of LAB project

Design summary

System volume: 834 m³, Hot Oil: Therminol 66

Supply temperature to users: 320 deg.C

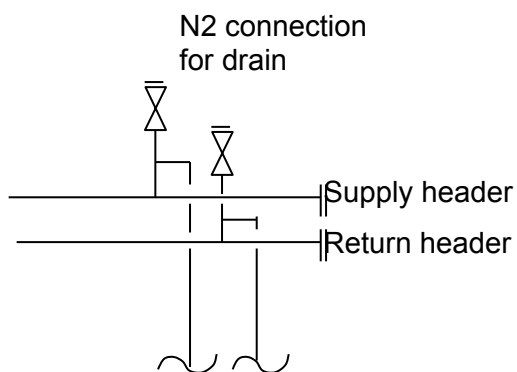
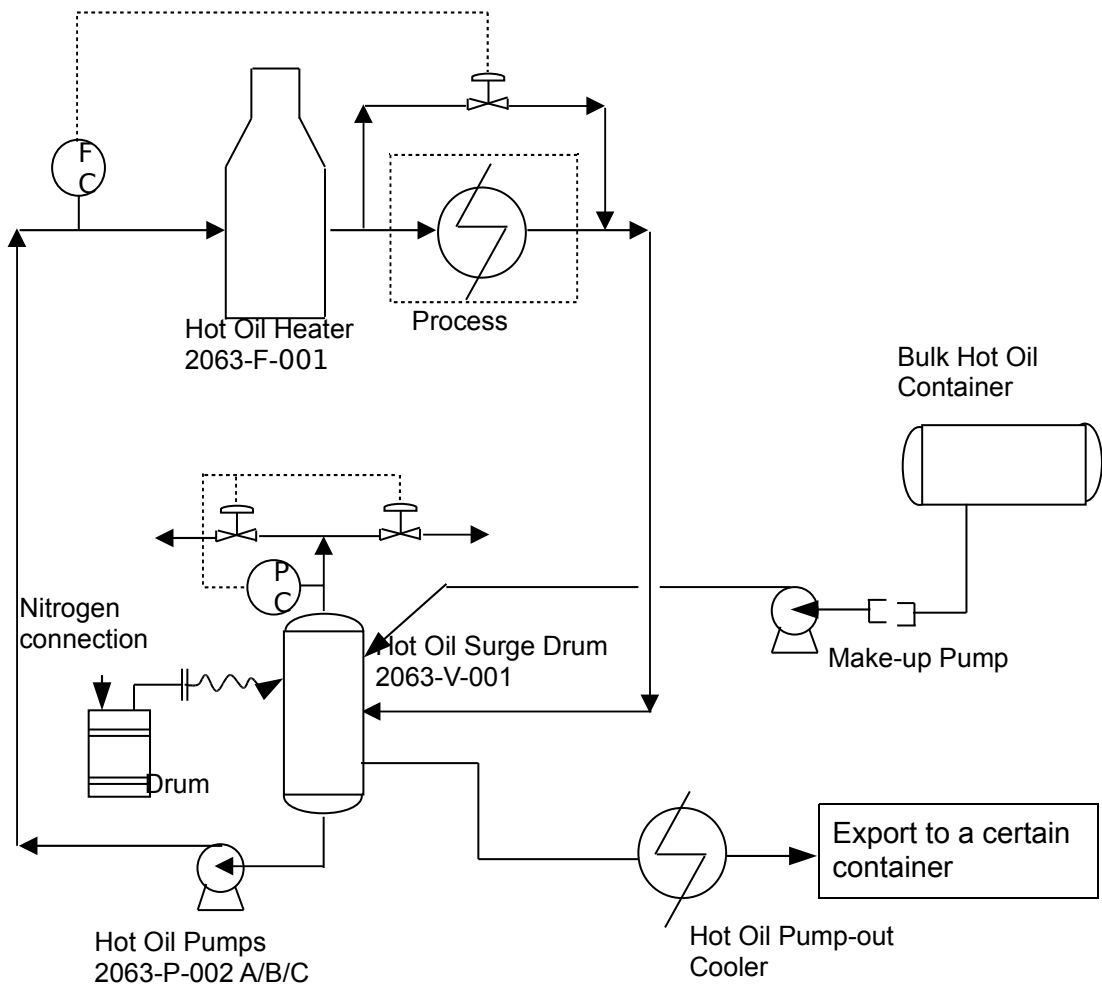
ITEM NO.	SERVICE	NO. REQ.	TYPE	DIMENSION IDxT.L (mm)	HEAT DUTY MM kcal/H	SURFACE AREA (m ²)	MATERIAL		DESIGN CONDITION			
							SHELL	TUBE	PRESS (kg/cm ² G)		TEMP (°C)	
									S.S	T.S	S.S	T.S
2063-E-001-1/-2	Hot Oil Pumpout Cooler	1+1	AES	600*4000	0.83	81.1	CS	90-10/ Cu-Ni	7.0	6.5	288	65

ITEM NO.	SERVICE	NO. REQ.	TYPE	DESIGN CONDITION	DIFF.PRES (KG/Cm2)	HEAD (m)	NPSHA (m)	CASE/ IMPELLER MAT'L	RATED POWER (KW)
				RATED CAPA. (m3/H)					
2063-P-002 A/B/C	Hot Oil Pumps	2+1	Cent. (Between Bearing)	2114.3	13.2	161.3	77	Steel/ 11-13%Cr	907.8
2063-P002ABC-P1	Auxiliary Lube Oil Pump	2+1							
2063-P002ABC-E1	Lube Oil Heater	2+1							
2063-P-003	Pumpout Pump	1	Cent.	4.4	3.8	38.5	3.4	Steel/ Steel	4.58
2063-P-004	Hot Oil Transfer pump	1	Cent.	11	3.5	34.7	3.4	Steel/ Steel	4.27

ITEM NO.	SERVICE	NO. REQ.	TYPE (CAPA.) (m ³)	DIMENSION Dia.xT.L (mm)	SHELL MAT'L	DESIGN CONDITION	
						PRESS. (kg/cm ² G)	TEMP. (°C)
2063-V-001	Hot Oil Surge Drum	1	Vert.	5000OD*1800 0	SA 515 GR.70	3.5/FV	360

ITEM NO.	SERVICE	NO. REQ.	TYPE	DIMENSION IDxT.L (mm)	CAPACITY	OTHER SPECIFICATION
2063-F-001	Hot Oil Heater	1	Radiant Convective (Vertical Box Type)		3,470,110 Kg/Hr	Heat Duty: 94.67 MMKcal/Hr <Coil Specification> Coil Design Pressure: 24.0 kg/cm ² G Design Temp.: 425 °C Tube Material: C.S.(ASTM A-106 Gr.B)
2063-G-001	Hot Oil Filter	1	Cartridge	390 X 1650	Max. 28,250 Kg/Hr	Design Pressure: 15.0 kg/cm ² G Design Temp.: 320 °C Material: C.S.

Hot oil schematic diagram of LAB Project



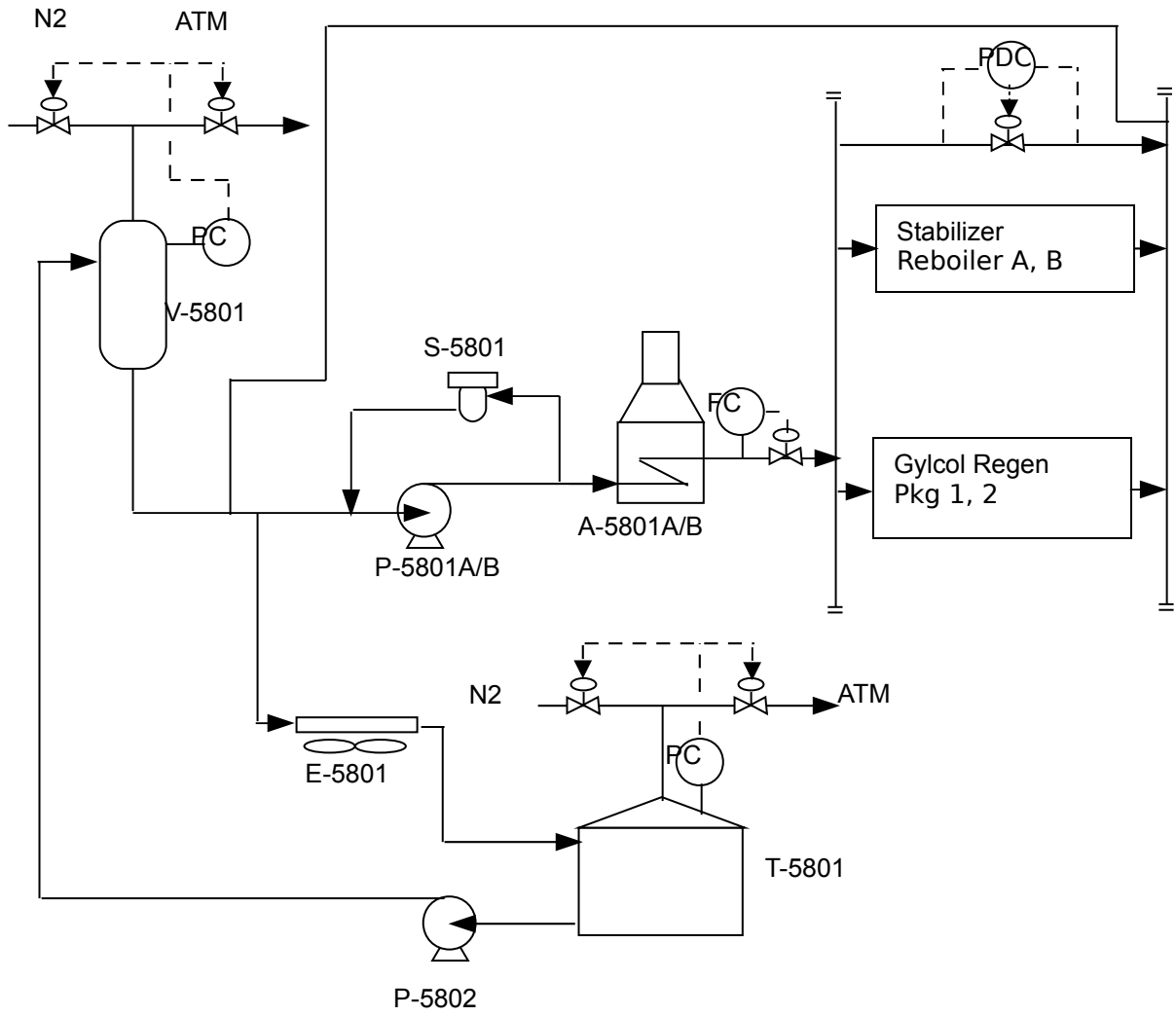
Connected to the Hot oil user:
All users have low point drain connection to pump-out by a Potable pump

6.4 Hot oil system summary of 이집트 칼다 project

Design summary

Hot Oil	
Oper. Temp	280 oC
Heat Duty	Eq. Short spec참고
System Vol	
Eq. Short Spec	Hot Oil Fired Heater Package (SA-A-5801A/B) 7812 kW per each unit (240 oC -> 280 oC) about 251 t/h Hot Oil Rundown Cooler (SA-E-5801) 13 t/h, 280 oC -> 60 oC Hot Oil Circulation Pumps (SA-P-5801A/B) 1 operationg, 1 standby Nor.: 372 m3/h, Rated: 440 m3/h Hot Oil Slim Stream Filter (SA-S-5801) 37.24 m3/h (10% of Circ. Pump normal capacity) Hot Oil Tank (SA-T-5801) 4500 mmID x 6000 mm H (about 84 m3 - HLL기준) Hot Oil Expansion Vessel (SA-V-5801) Vertical, 2200 mmID x 7100 mm H

Hot oil schematic diagram of 이집트 칼다 Project

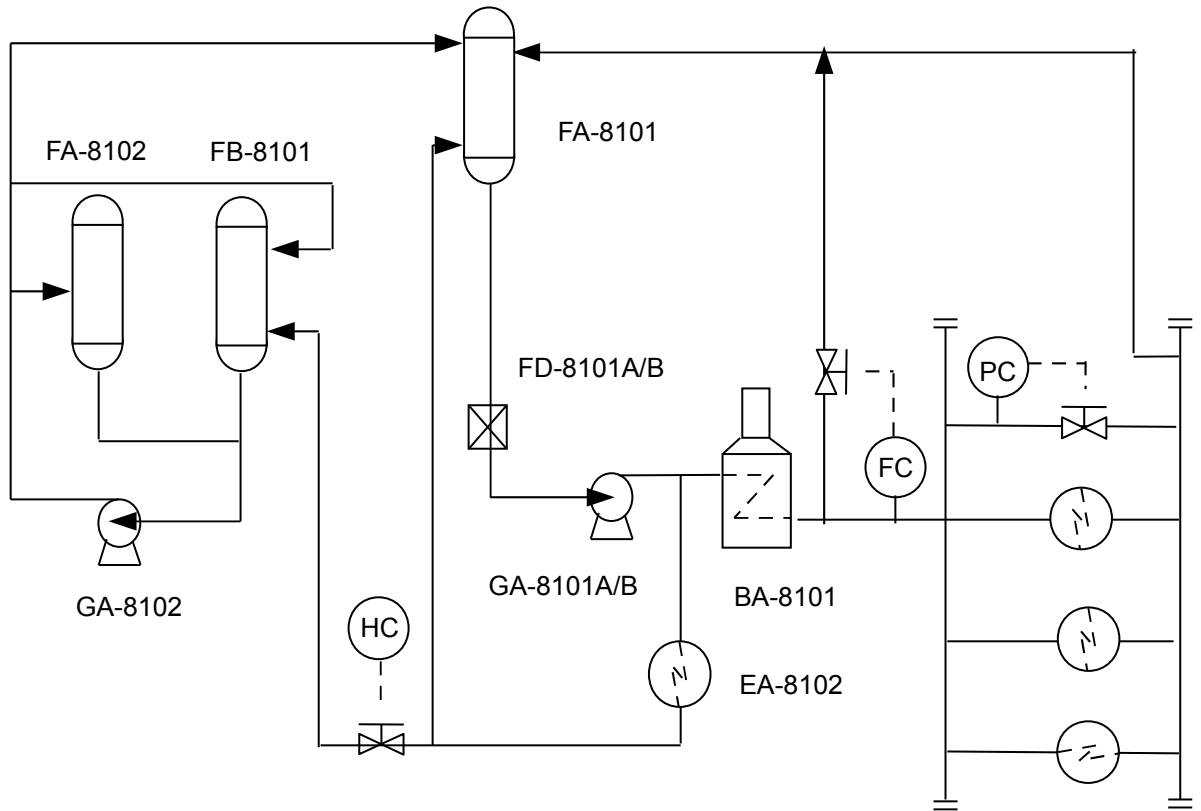


6.5 Hot oil system summary of 삼성석유 TA/PTA (서산) project

Design summary

Equipment Tag No.	Service Name	Quantity		Type	Design	Design condition	
		Oper.	S'by			Press. Kg/cm2g	Temp. °C
BA 8101	Hot Oil Heater	1	0		Heat duty: 25 MMKcal/h Size: 7030ID*40968H Material: (BODY)A36 GRADE STEEL (COIL):A106Gr.B Heat Transfer Medium ThermS-600 (290 °C → 316 °C) Flowrate (max. / nor.): 1,600/1,544.5 ton/h Press. Drop (max. / nor.): 2.0/1.8 kg/cm2 Integrated with steam recovery system	12	360
EA 8102	Hot Oil Cooler	1	0	BEU	Size: 500ID x 4880L Surface area: 42 m2	12 / 8	360 / 80
FA- 8101	Hot Oil Expansion Drum	1	0	Vert.	Size: 3800ID x 5000H	3.0/FV	360
FA 8102	Hot Oil Blow Down Drum	1	0	Vert.	Size: 3800ID x 5000H	FW	360
FB 8101	Hot oil Storage Drum	1	0	Vert..	Size: 2200ID x 5000H	3.0/FV	360
FD 8101 A/B	GA-8101A/B Suction Filter	1	1		Flowrate: 1800 kg/h	5.0/FV	360
GA 8101 A/B	Hot oil Circulation pump	1	1	Cent.	Flowrate: 1800 m3/h Differential head: 65 m Power:, 450 kW (motor)	12	360
GA 8102	Hot Oil Charge Pump	1	0	-Cent.	Flowrate: 10 m3/h Differential head: 34 m Power: 3.7 kW (motor)	12	360

Hot oil schematic diagram of 삼성석유화학 TA/PTA Project



7. REFERENCE

- 베트남 가스 Project Operator training 자료
- Shell사의 HTF 설계가이드
- 산업안전공단 열매체 시스템 설계 자료
- Process Utility Systems, by Jack Broughton
- 기타 Vendor Design Guide