PETROCHEMICALS
PLANTS

FROM COMMISSIONING
TO NORMAL OPERATIONS

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At the date of authorizing he was working as Production and Operations Assistant Manager at the Egyptian Indian Polyethylene Terephthalate (EIPET) –Industrial free zone – Ain Elsokhna- Egypt ,he started there at 2013 as Senior Production Engineer.
And he was worked from 2008 to 2013 at TCI-SANMAR Chemicals, in the S-PVC polymerization plant , as operation Engineer
And he started authorizing this book in order for documenting his experiences in the field of petrochemicals projects commissioning and startup, with the first schematic procedures in one book for the common equipments and units in the petrochemicals industry.

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Some of this chapter content referenced to process control by William Dunn

Content

As usual most of Operation Engineers who joined a running plant they are trained for being as shift operation Engineers, how to operate a unit or how to manage several units operation activities or how to lead his shift manpower and their scheduled jobs. from the Engineering view this is one phase only of any refining or petrochemicals projects and usually this is the last stage of the project called “Normal operation phase”.

In this course we prepared what would most of Shift Operation Engineers like to see, and what is required to open their view angel about their running Plants, accurately and well organized explanation sequence of the Refining and Petrochemicals Projects phases from A to Z , and What is the role of the owner’s Operation Engineers during every phase of the project .

The sources of this course data are not a definite academic sources but actually this data were collected in around seven years of setting a mega petrochemicals plants with modern technologies applications from construction till production implementations, as we define fundamental and practical Process Engineering according to the project sequence and downstream& upstream troubleshooting experiences , we collected this in the way which helps to bring the Green hands graduates up-to the targeted professionalism of this career, and also helps the operation teams to get a deep practical understanding for their Units operations .

This Course will be divided into 4 parties , every part will explain one project section which can be studied individually as per your career requirements , hoping this will be more helpful for all of you.

Chapter -1: Project Construction &Pre-commissioning Phase.

Chapter-2: commissioning and Startup Phase.

Chapter-3: Petrochemicals Reactors types, operations and troubleshooting.

Chapter-4: Unit operation and downstream troubleshooting.

Chapter-5: Process Control for Operation team beginners

Chapter 1

Petrochemicals Plants and oil Refineries

Project Construction & Precommissioning Phase.

Project Phase Stages:

Any plant must pass through all these phases to be properly managed with total controlled specifications.

1- **Project Planning**.
2- **Construction and Precommissioning**

These phases may be applied in same way or by other arrangements , as every project has its financial and logistics conditions which control the management of the per-listed phases.

The Operation or Production Engineer role will vary from project to other and from phase to next one as per designation and responsibilities given. But we will illustrate the normal role for juniors and seniors not for managerial level.

1- PROJECT PLANNING:-

This the first and the most important stage of any Petrochemicals or Refining plant , according to the desired product type , quantity ,quality and the strength of the asset financed for this project the owners are asking for project planning specialists who are making all stages assessment and giving variability of all stages factors compared with time schedule and cost expected and final project wings assembly .

Project Planning steps were clearly defined like following

1-1 Safety Risk Assessment

_like HAZOP :(HAZARD &OPERABILITY analysis)any plant must has its accurately defined data of what is the process hazards and where the most convenient environment for installation, and what is safety precautions to be taken during installation and operations, this is considered to be the first important study of the required process.

-like also the pre-construction environmental studies what the area nature? (wind strength carried with dust or sand , earthquake activity, raining density probabilities at different year seasons) to take the protection safe methods for all areas of the plant. And also determine the safety precautions and bring proper safety PPE for all team at different jobs conditions.

1-2 Process System Definition

_@ this stage Choosing the most optimized process technology according the considerations of the HOZOP and the expected cost for all stages , the technology supplier or the consultant is drawing the P&ID Master set ,(PIPING and Instruments Diagram) as this high importance pinned drawing for the plant setup and operations at all phases of the project. Fig.1-1

-P&ID modifications which is applied during the drawing revisions by technology supplier with the main contractors to reach to the last revision of the P&ID (the master set) of the optimum cost according to calculations ,applications and smooth operation .

1-3 Completion Priorities

-Professional Planning for this stage is necessary ,

-what is the priorities of the plant different units construction to avoid scheduled commissioning disturbance ?.

-What ever the delaying of any erection or fabrications jobs, the project planning team must play the main role to overcome the conflict of the construction timing ,

so the technical team must decide what will be plan B to face the delaying of any project running jobs avoiding the project over cost and losses.

-so the construction completion priorities of any project is determined by one principal "what will help the project progress to commissioning stage" like completion of utilities which used for testing of finished fabrications.

-according to the planned completion sequence in-parallel jobs to be full controlled by providing continuous technical support and avoiding material accidentalshortage or damage by proper handling and goodstorage for easy issuing and inventory.

1-4-Project Software arrangements:

-All available data of the project must be digitally controlled to keep the data source away from missing or damage .

-during the construction of the plant all drawings like P&ID , ISOMETRIC,PIPING LAYOUT ,Nozzle orientation &EQUIPMENT LAYOUT and other documents like Excel sheets or catalogs must be kept organized to easy get and transfer the data of any tiny part of the plant.

-Master software sources to be guaranteed , secured and continuous updated by most recent modifications or new data sheets growing by the project progress.

-The progress reports of the projectto be honestly collected to give final frame for easy determining the total progress percentage, this progress reports are normally filled and collected weekly ,to assure that the plan is followed and this reports to be discussed every technical meeting with the technology supplier and the main contractors.

1-5-Project documentation arrangements:

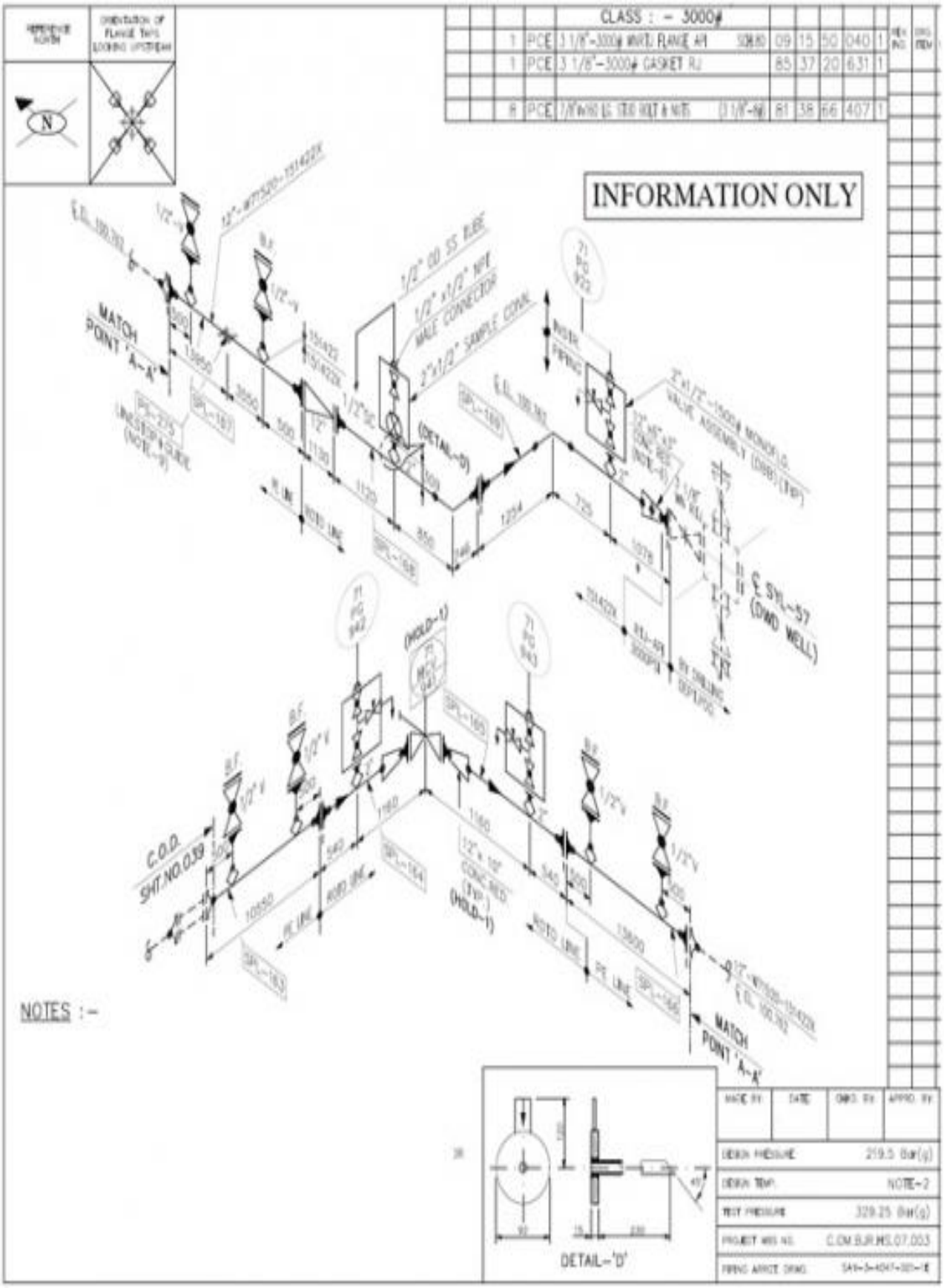
-Engineers have to arrange their tools for the stage of project what are the required documents for them and what is required from them so we will illustrate this as following:-

A-Engineering Documents required for following the project activities:

- Time schedule (project construction priorities)
- Drawings(P&ID , ISO.,LAYOUTS, TANKS NOZZLE ORIEN.,Rotary Equipment assembly..etc.,)
- Equipment specifications lists
- Piping loops lists.
- Check lists templates.
- Punch list , point out templates.
- Pre-commissioning procedures.
- Commissioning procedures.
- Emergency Response procedures .
- Safety procedures, and different work permits templates.
- Progress report templates.
- Test records templates.
- SOP (Standard Operating Manual) master copy from technology suppliers.
- DSC interlock lists , for checking and studying.

HERE some drawing samples for checking.

1- P&ID legends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DETAIL-'D'
NOTES :-

B-What is the main role of the operation Engineers and what is required from them?

- Dividing the project into small areas to be able to easy following and proper progress reports.
- Using the drawings of the area to assure that the contractor is following the plan.
- Report all area erection and fabrications for all equipment or piping using Checklists.
- Report any conflicts or field point out using punch lists .
- Report every area progress report for higher technical levels .
- Finished piping loops to be scheduled for Precommissioning.
- Following erected stationary and rotary equipment and prepare for Precommissioning ,and report what is ready for next stage.
- Following Mechanical , Instruments , electrical completion priorities and Co-ordination reports.

1-6-Manpower tree plan:

-Manpower planning is a high importance job to be managed by both technical and HR managers ,as every plant has many areas and every area has one or several units to be operated professionally and to get this level of operation we have to determine some important points:

- What is current phase of the project & who will fit the required jobs ? , most of plants hire the Engineering levels only at the early phases of the project, and technician, operator levels are hired later at start of commissioning phase or after that as per type of commissioning contract.
- The manpower tree of every department is applied according to the technology supplier operating tactics and employees job description is clearly determined and proper training sessions to be planned for all the technical team.
- Operation , Mechanical ,ınstrumentation and Electrical teams to be clearly communicated with collaborated Engineers team and if required managerial

level , to instruct all others about their responsibilities towards the Co-jobs at all stages .

- Authorities (who is permitted to do what?) This point also to be discussed and determined under the supervision of the managers of departments who is qualified for big critical jobs like emergency troubleshooting, and what is the level of the authority given to a definite employee at definite urgent or permanent jobs.

1-7-Material Used every stage:

-Through all the project stages the operation team leaders are determining what is stage materials required like commissioning tools (hoses-gaskets-toolkits-gauges).

-these materials preparing and issuing must be managed strictly applying convenient software network system for best control.

1-8-Equipment needed for testing:

-Special equipment like pressurizing jet pumps or Vacuum leak detectors to be provided at the proper stage with the using procedures avoiding failures or troubleshooting.

All these 8 points are the main planning points required from operations team leaders according to project phase.

2-Plant Civil Construction Stage:

2-1 -infrastructure

2-2 -concrete construction

2-3-Steel structure

2-1-Infrastructure foundation:

►The utilities which is needed or planned to be needed for the factory at future must be put in the construction way , like Water & Waste water lines , Natural gas or Crude oil lines from OSBL (outside battery limit) to ISBL(inside battery limit) or vice versa.

►Usually Utilities are like veins and arteries , from this view the conflict isn't permitted, all the feeders and bleeders to the in-out headers specially buried ones of the utilities must be clearly set up from outside to the different users inside the plant .

►Process Safety during infrastructure foundation, must be applied ,like it isn't permitted to cross pass of electric buried cables with flammable material pipe line and corrosive materials buried lines must have proper safety distance with other buried service lines which can be affected badly.

2-2-Concrete construction :

At the first milestone of the project implementation stage , the Civil constructions are Carried out with directly supervision from the owner side , actually the Operations or Process role not that much bigger but

it is highly important,, the technical team of the owner taking the process point of view at this stage

►as all Civil constructions for the basis of the plant must not conflict with any of future electrical or mechanical or instrumentation construction layers, applying the construction planning for the factory future.

►The drawings of the big equipment in the field specially ,the nozzle orientation drawings must be checked every growing step for the Civil constructions,, nozzles must be clearly find their pass way through the concrete,, or we will face some damage either for concrete or for the body of the equipment ,and whatever we will face we will miss time , workers effort & money not planned waste.

►And for all implemented parts of concrete Safety of process sequence and process team after running the plant must be applied ,very small things can annoy big teams.

2-3-Steel construction :

►Mostly same role during concrete construction, but only the pipe Racks has to be followed every stage any setting up must be typical to which shown on the pipe Rack drawings and beams numbering has to be signed and sequenced properly, for future facilitate of piping fabrications and future easy operation .

3- Mechanical construction & Precommissioning Stage:

These are the general mechanical plant contents where we divided and arranged for proper following for all the project constructions activities.

3-1-Tanks &vessels

3-2-Stationary unit Equipment

3-3-Rotating Equipment and rotating parts of stationary equipments

3-4-Piping fabrications & fittings

►►Pre-commissioning Professional Procedures:

For Following the project progress properly we have to divide the project into Areas , and Every Area has its Equipment , Instrument and Piping lists & drawings.

We also divide the commissioning manpower into teams every team will be responsible for specific area, and so every team will have his own area checking drawings and proper documentation software and hardware.

Then the procedure to follow and check the area erection and fabrication progress by following Steps:

1-Equipement description:

-Equipment main function in the process downstream, of the specified area.
-Equipment Shape , volume and static or rotating.
-Equipment main parts outer body and internal parts and design details not.

2-Pre-Commissioning checking steps:

-Grouting proceeding.
- Equipment body bolting with cold bolting specified torque then hot bolting to be done during plant commissioning and supporting to the building.
-Equipment outer body checking after fixing design details and free of defection.
-Equipment fixed interiors design ,and defection free , and the assembled part inside the equipment is same as design and free of defections.
-Equipment internals free of dirties ,fabrication residuals, and proper clean from inside.
-Internal parts assembly progress.
-Primary bolting and gasketing for the equipment manholes and boxing progress.

3-Used Drawings for checking Equipments Precommissioning:

-P&ID
-Equipment Mechanical specification drawing.
-Nozzle orientation.
-Plant Layout.(plan view)

And for following piping fabrications and erections some other drawing will be needed also:

-Piping isometric drawing.
-Piping layout drawing.

4-<u>Used schematic documents for daily reporting</u>:
-**<u>Check list scheme</u> :** contains the specified cells for Equipment area and its tag number
and checking cells for grouting ,bolting, supporting ,gasketing and boxing up daily progress hardware copy.

-**<u>Progress Report</u>** <u>Daily ,weekly and monthly</u>:
For equipments or for piping loops
this is soft copy report for data collection of daily checking reports to give total project implementation percentage, and checking the project is proper going or there is any problem.

*<u>**Piping Loop lists for progress reporting:**</u> this soft copy excel sheet lists contain a definite number of piping spools with the same service material and with same metal type and with also same operating conditions .
with the loop spools definition tag names every spool to be checked daily with pre-mentioned drawings used for piping fabrication checking, ever

-<u>**Point out list** (re-woks)</u> : this scheme contains cells for equipment tag number and area ,
and cells body different design parts, body missed parts body defects or damaged parts due to manufacturing problem or transferring or erection damage.
Point out lists are daily converted from hard copies into soft copies , and to be sent every day end to the managerial levels of all project participants (owner side, technology supplier side,) and this will be handled to the responsible Vendors or contractors.

3-1 Tanks & vessels

1-Equipment description:

Tanks and vessels are prefabricated or fabricated in the field and according to the service type the specifications and the volume of these tanks are applied.

●many types of tanks are used in this industry and scientifically are divided to types as per there:

◊- Setting direction like (horizontal or vertical tanks)

◊-Operating conditions (pressurized or Atmospheric)

◊-Type of service applied:

-Storage only clear from inside.

–Separation drum special internal design.

–Preparation tanks with cooling or heating facility only.

–Preparation tanks with mixing agitator facility.

◊-shape of Tanks head:

--Cylindrical tanks head and bottom like cylindrical vertical storage tanks. -(fixed roof or floating roof)

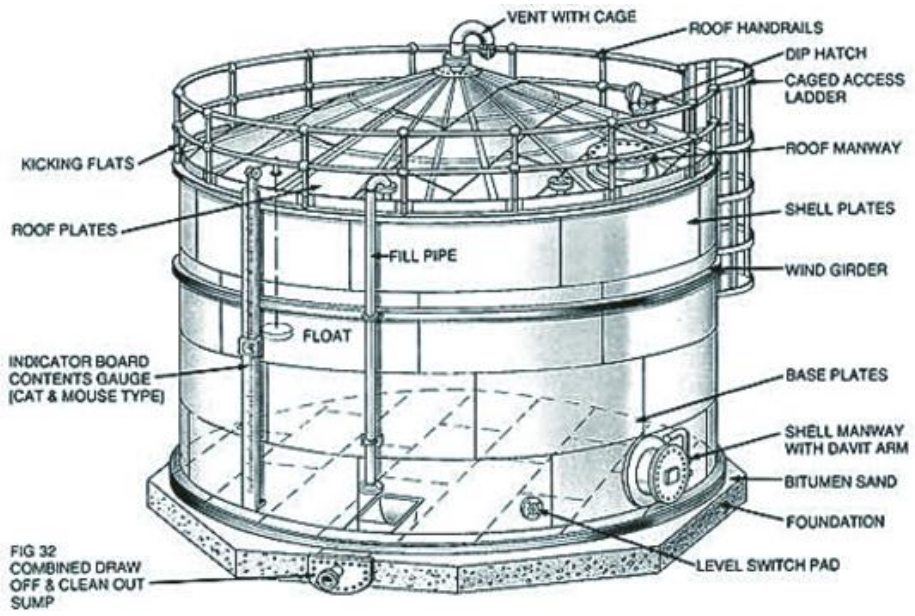
- and other types of head /bottom for both vertical and horizontal like (hemispherical , torispherical , spherical , elliptical, conical) all these shapes will make the different of liquid levels inside the tank and every shape has its own Level calibration equation.

Spherical tanks

Torspherical head tank

conical bottom

Fixed roof doom tank



Fixed roof tank

2-Pre-commissioning checking

●After finishing the civil works for tank grouting it is very important to use specified tank nozzle orientation drawing for determining the proper direction of the outer nozzles to be smoothly aligned with the further connected pipes or ducts.

●checking the external body of the tank free of buckling and nozzles not damaged , if any point out to be reported directly.

●checking for the tank internals same as design or not , and if there is some internal special parts like over flow baffles ,mist arrestors or internal strainer…..etc ,these all interiors are perfect or not.

●during the grouting of the tank the we have to check this tank axis is actually as per drawings , because some services need controlled

slope for the tank body toward definite direction like tank outlet direction, and for this using the level balance on the body of the tank to check it is perfect or need some shims to be added to the grouting.

●for hot service applications the insulation has to be applied with proper coordination with other fabrications activities, not to hide any flange and miss time and effort during project.

3-2 Stationary Equipments:

Those equipments is an acting active arm in the plant , many types and more details to be checked here we will try to talk about some of them.

►3-2-A Distillation Towers ,stripping columns :

1-Equipment description:

The columns and towers are stationery pressurized big vessels so during start up and shutdown or miss-operation these equipments can face hammering which can cause damage for some connections , so their supporting joints and bolts to be proper fitted.

Towers and columns are special designed stationary equipment for different separation purposes, with the applying of the meaning of heat transfer or mass transfer or both theories which enhance and promote the fluids separation according to the different physical and chemical attitudes of every material in the mixture inside the tower or column different vertical stages .

–The towers and columns popular interior parts like:

●Trays (sieve or perphorated trays, valve trays , bubble cap trays……)for checking these interiors we use the equipment isometric drawing with its cross sections , the identified name plate for the tower will clarify its main dimensions and its design operating conditions and capacities but the interiors details are listed in the drawings like (

number of trays –number of perforates – number of valves or bubble caps per tray).

The shape of the tray itself is also in details illustrated in the drawings, the weirs and other fixed interiors are illustrated also in the drawing going with the drawing and with confined space safety permits and specified PPE we can check the erection inside is going according to the design and we point out any body defects or misarranging of the trays . as the trays main function is to allow a definite required tangency residence time between vapor and liquid for proper separation and also controlling the flows of both liquid and vapor on every tray so it must be handled without any small defect.

●Packing is also another internal content of some columns for the functions of absorption or adsorption, every process function has its packing type like

(molecular sieve packing , fixed Teflon porous packing, rush rings packing, //or corrugated sheet, plastic balls, ceramic balls, mesh pads for particulate removal and mist elimination)

The functions of tower packing are (mist elimination , acid gas scrubbing , catalytic gas scrubbing , distillation , precipitation, particulate removal) every function has its packing type , shape and dimensions these specifications are to be checked by the specified drawings , rather than the other interiors like packing support and liquid spray and liquid distributer to be clarified are typical to design and no defects.

●Other important towers and columns common interiors to be checked , like:

-(Liquid spray nozzles to be checked for no defects and proper spray direction)

-(bottom internal Reboiler coil not to be defected or damaged)

-(internal instrumentation elements like Thermowell elements along the the tower –Pressure rapture Desks–Levels indication internal elements) and usually instruments erection and calibration started with the commissioning phase reaching to first start up , after finishing the a round area fabrications piping and supports , not to damage or lose any instrument as these instruments are small and very expensive ,defections are costly repair , so in petrochemicals projects implementation schedules , we will find the instrumentation erection and calibration started with the commissioning stage and in parallel with DCS setting up progress.

2-Pre-commissioning checking:

●we treat their outer bodies like shaped vessels the checking steps we are following during tank grouting ,fixing to the plant building and supporting progress to be reported.

●outer parts to be checked free of defections and same as design after body and erection as we motioned before, some special details to be followed for distillation towers and stripping column from outer side there is flanges specified for sight glass this to be checked and delay its erecting till final boxing up, also top safety reliefs and rapture desks are not defected.

●all designed internals to be properly checked like:

-trays sizing (dimension and openings numbers and diameters ,weirs ,tray orientation and supporting are properly fitted), checked ok.

-number of trays, checked ok.
-depth of packing, and packing material are same to design, checked ok.
-spray nozzles sizing and positioned to proper flange opening& free of defects, checked ok.
-inlet& outlet feeds nozzles aren't defected, and fitted to the specified flange, checked ok.
-bottom heating coil , or internal reboiler is fitted properly and free of defects , checked ok.

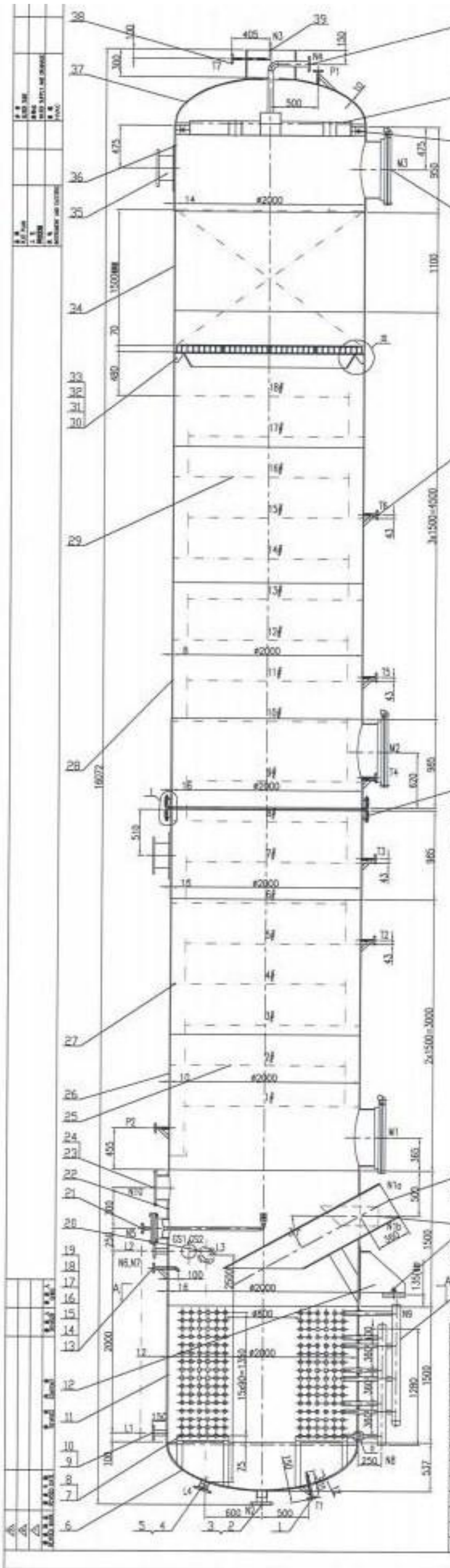
●cleaning :assure column or tower is perfectly clean from inside , and inspection cleaning report to be signed from the inspection side , then

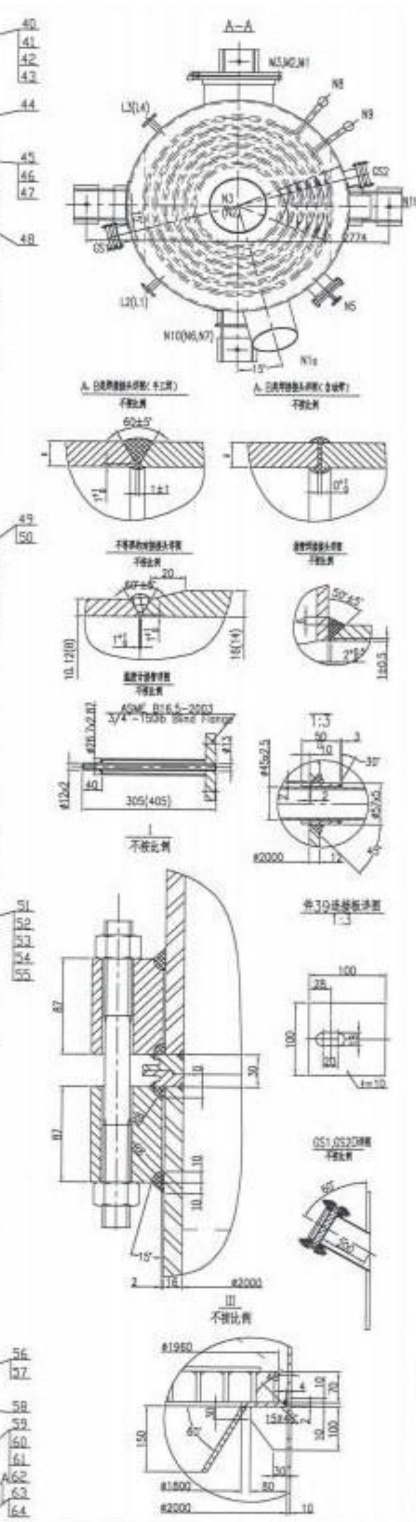
●primary Boxing up of manholes and sight glasses to blinded till commissioning stage.

●primary cold bolting to be proceeded and with the proper gasketing according to the process conditions.

●for hot service applications the insulation has to be applied with proper coordination with other fabrications activities, not to hide any flange and miss time and effort during project.

Tower Erection & inspection





[illegible]	HG20584-1998 [illegible] GB150-1998 [illegible]				
	container	coil		container	coil
Work Pressure MPa	0.015	0.45	heat interchanging area		53.1 m²
Design Pressure MPa	0.2	0.6	[illegible]		
Work Temperature ℃	220	290	[illegible]	0.85	1
Design Temperature ℃	265	330	Volume m³		0.5
[illegible] mm	0	0	[illegible]	/	
Medium	EG	T-66	[illegible] MPa	/	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] HG20583-1998	
Density kg/m³	1080	840	[illegible]	0Cr4 0025 [illegible]	G28
[illegible] MPa	0.28	0.91	[illegible]	[illegible]	[illegible]
[illegible] MPa	0.2	0.6	[illegible]	[illegible]	[illegible]
[illegible]	JB/T4709-2000		A,B [illegible]	JB/T4730.3-2005	[illegible]
[illegible] 0Cr18Ni9 [illegible]	A102	H0Cr21Ni10 / HJ260	[illegible] 100%	JB/T4730.3-2005	[illegible]
[illegible]	J427	/ /	[illegible] 100%	JB/T4730.3-2005	[illegible]
[illegible] 0Cr18Ni9 [illegible]	A302	/ /	[illegible] 100%	JB/T4730.5-2005	[illegible]
			[illegible]	7[illegible](0.1g)	
Empty Wt Kg	13975 [illegible]		[illegible] mm	150	
[illegible] Kg	12817 [illegible]		[illegible]	[illegible]	
[illegible] Kg			[illegible]	/	
[illegible] Kg			[illegible]	Ra50	
[illegible]	[illegible]		[illegible]	JB/T4711-2003	

[illegible]:

1 [illegible] /2 [illegible]
3 [illegible]
4 [illegible] /5 [illegible] 26-27 [illegible]
6 [illegible] JB/T4702-2000 [illegible] C-RF 2000-0.6 [illegible]
7 [illegible] 1mm;
8 [illegible]

List of nozzles

Symbol	Nominal Size	Flange Standards	Sealing surface form	For or name	joint style	Pipe size	[illegible]
N1a	16"		[illegible]/Welding	gas inlet	052	[illegible]	see chart
N1b	8"		[illegible]/Welding	gas inlet	052	[illegible]	200
N2	4"-150lb	ASME B16.5-2003 Slip On Flanges	RF	liquid outlet	G2	[illegible]	150
N3	20"		[illegible]/Welding	gas outlet	G2	[illegible]	see chart
N4	2"-150lb	ASME B16.5-2003 Slip On Flanges	RF	[illegible]	G2	[illegible]	150
N5	1"-150lb	ASME B16.5-2003 Slip On Flanges	RF	EOR inlet	G2	[illegible]	150
N6	1"-150lb	ASME B16.5-2003 Slip On Flanges	RF	EOF inlet	G2	[illegible]	150
N7	1 1/2"-150lb	ASME B16.5-2003 Slip On Flanges	RF	EGC inlet	G2	[illegible]	150
N8	6"		[illegible]/Welding	HTM inlet	G2	[illegible]	see chart
N9	6"		[illegible]/Welding	HTM outlet	G2	[illegible]	see chart
N10	10"-150lb	ASME B16.5-2003 Slip On Flanges	RF	Safety Valves	G2	[illegible]	see chart
L1~2	2"-150lb	ASME B16.5-2003 Slip On Flanges	RF	liquid indicator	G2	[illegible]	see chart
L3~4	3"-150lb	ASME B16.5-2003 Slip On Flanges	RF	liquid indicator	G2	[illegible]	100
T1~7	3/4"-150lb	ASME B16.5-2003 Slip On Flanges	RF	Thermometer	G2,G49	[illegible]	150
GS1~2	150	GHJ502-86	/	sight glass	G2,G49	/	150
P1~2	3/4"-150lb	ASME B16.5-2003 Blind Flanges	RF	[illegible]	G2,G49	[illegible]	150
M1~3	600-1.0	HG21517-2005	M/FM	manhole	G2		150

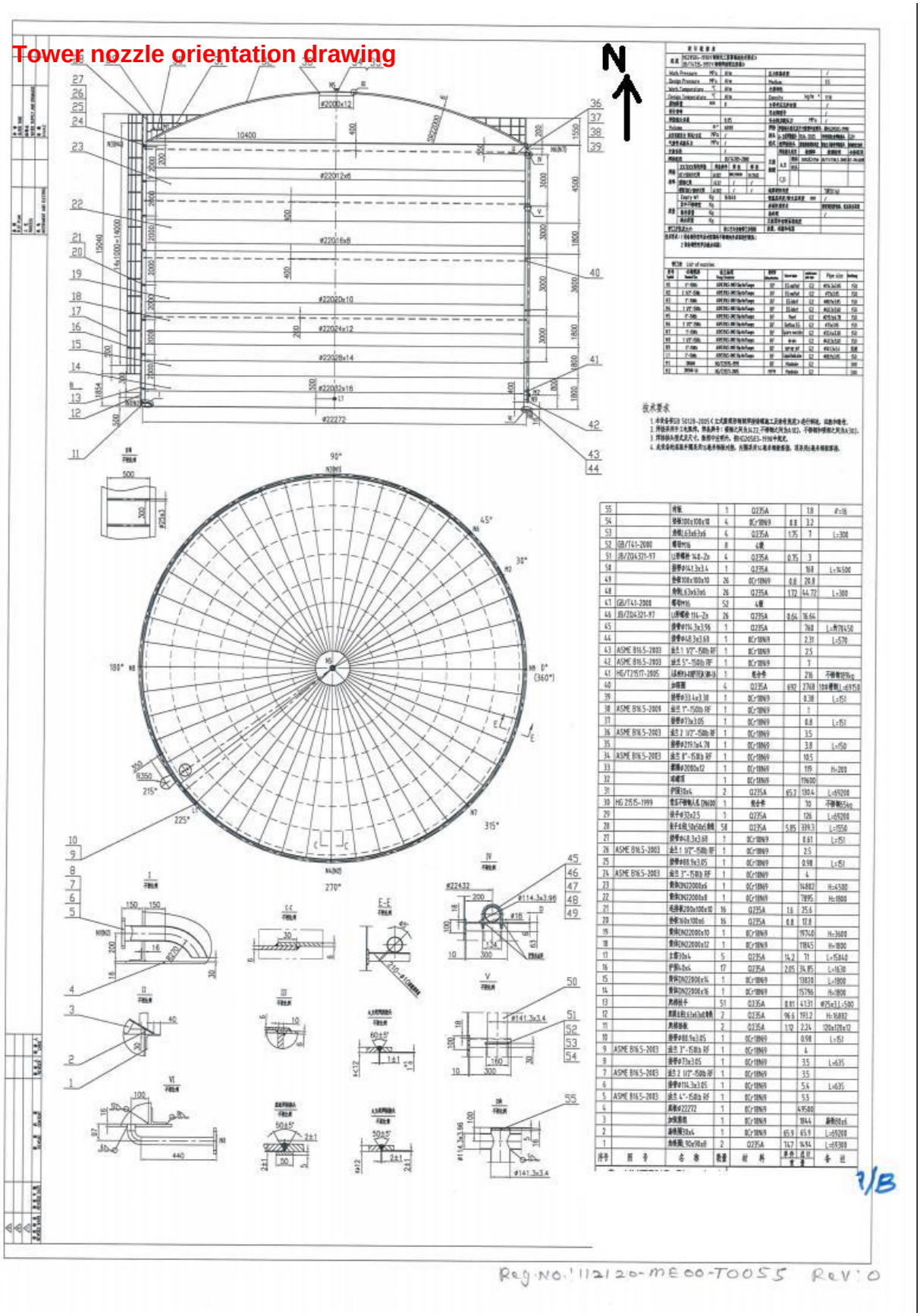
49	ASME B16.5-2003	[illegible] 3/4"-150lb RF	8	0Cr18Ni9[illegible]	1	8	
48	HG/T21517-2005	[illegible]	3	CS/0Cr18Ni9	217	651	20/197
47	GB/T6170-2000	[illegible] M16	8	A2-70			
46	GB/T5781-2000	[illegible] M16x60	8	A2-70			[illegible]
45		[illegible] 100x100x10	8	0Cr18Ni9	0.8	6.4	
44	04A/B-C01-07	[illegible]	1	0Cr18Ni9		212.4	
43		[illegible] ø60.3x3.58	1	0Cr18Ni9		2.4	L=460
42	GB/T12459-2005	[illegible] 2"-Sch40 [illegible]	1	0Cr18Ni9		0.5	
41		[illegible] ø60.3x3.58	1	0Cr18Ni9		1.68	L=335
40	ASME B16.5-2003	[illegible] 2"-150lb RF	1	0Cr18Ni9		2.5	
39		[illegible] ø508x9.53	1	0Cr18Ni9		42.5	L=328
38		[illegible]	1	0Cr18Ni9		1.2	
37	JB/T4746-2002	[illegible] EHA2000x10	1	0Cr18Ni9		345.3	
36		[illegible] DN2000x14	1	0Cr18Ni9		316.1	H=450
35	HG/T21574-2008	[illegible] AXA-250-14	4	20/0Cr18Ni9	52.3	209.2	34.9/17.4
34		[illegible] DN2000x8	1	0Cr18Ni9		440.2	H=1100
33		[illegible]	1	0Cr18Ni9		74.3	
32		[illegible]	1	0Cr18Ni9		45.3	
31		[illegible] δ=10	8	0Cr18Ni9	0.49	3.9	[illegible]
30	04A/B-C01-06	[illegible]	1	0Cr18Ni9		354.2	
29	04A/B-C01-05	[illegible] 10~18#	9	0Cr18Ni9	82.2	739.8	[illegible]
28		[illegible] DN2000x8	3	0Cr18Ni9	600.3	1800.9	H=1500
27	04A/B-C01-04	[illegible]	1	0Cr18Ni9		1482.1	
26		[illegible] DN2000x10	2	0Cr18Ni9	751.1	1502.2	H=1500
25	04A/B-C01-03	[illegible] 1~9#	9	0Cr18Ni9	82.2	739.8	[illegible]
24		[illegible] ø273x6.35	1	0Cr18Ni9		6.26	L=150
23	ASME B16.5-2003	[illegible] 10"-150lb RF	1	0Cr18Ni9[illegible]		14	
22		[illegible] DN2000x16	1	0Cr18Ni9		1205.4	H=1500
21	04A/B-C01-02	[illegible]	1	Q235B/0Cr18Ni9	38.6	38.6	16.5/22.1
20	GHJ502-86	[illegible] Pg10 Dg150	2	0Cr18Ni9			
19	GB/T12459-2005	[illegible] 1 1/2"-Sch40 [illegible]	1	0Cr18Ni9			
18		[illegible] ø48.3x3.68	1	0Cr18Ni9	0.9	0.9	L=223
17	ASME B16.5-2003	[illegible] 1 1/2"-150lb RF	1	0Cr18Ni9		2	
16		[illegible] 30x4	28	0Cr18Ni9			L=150
15	GB/T12459-2005	[illegible] 1"-3 [illegible]	1	0Cr18Ni9			
14		[illegible] ø33.4x3.38	1	0Cr18Ni9	0.56	0.56	L=223
13	ASME B16.5-2003	[illegible] 1"-150lb RF	1	0Cr18Ni9[illegible]	1.5	1.5	
12	JB/T4712.3-2007	[illegible] C6	4	Q235A/0Cr18Ni9	74.8	299.2	50.4/24.4
11		[illegible] DN2000x12	1	0Cr18Ni9		902.2	H=1500
10		[illegible] ø60.3x3.58	2	0Cr18Ni9	0.75	1.5	L=150
9	ASME B16.5-2003	[illegible] 2"-150lb RF	2	0Cr18Ni9[illegible]	3	6	
8		[illegible] ø57x5	8	0Cr18Ni9		0.3	L=50
7	04A/B-C01-01	[illegible]	1	0Cr18Ni9		998.2	L=381[illegible]
6	JB/T4746-2002	[illegible] EHA2000x12	1	0Cr18Ni9		415.4	
5		[illegible] ø88.9x3.96	2	0Cr18Ni9	0.83	1.66	L=100
4	ASME B16.5-2003	[illegible] 3"-150lb RF	2	0Cr18Ni9[illegible]	4	8	
3		[illegible] ø114.3x3.96	1	0Cr18Ni9		1.62	L=150
2	ASME B16.5-2003	[illegible] 4"-150lb RF	1	0Cr18Ni9[illegible]		4.5	
1		[illegible]	1	0Cr18Ni9		1.2	
序号	代号	名称	数量	材料	[illegible]	[illegible]	备注

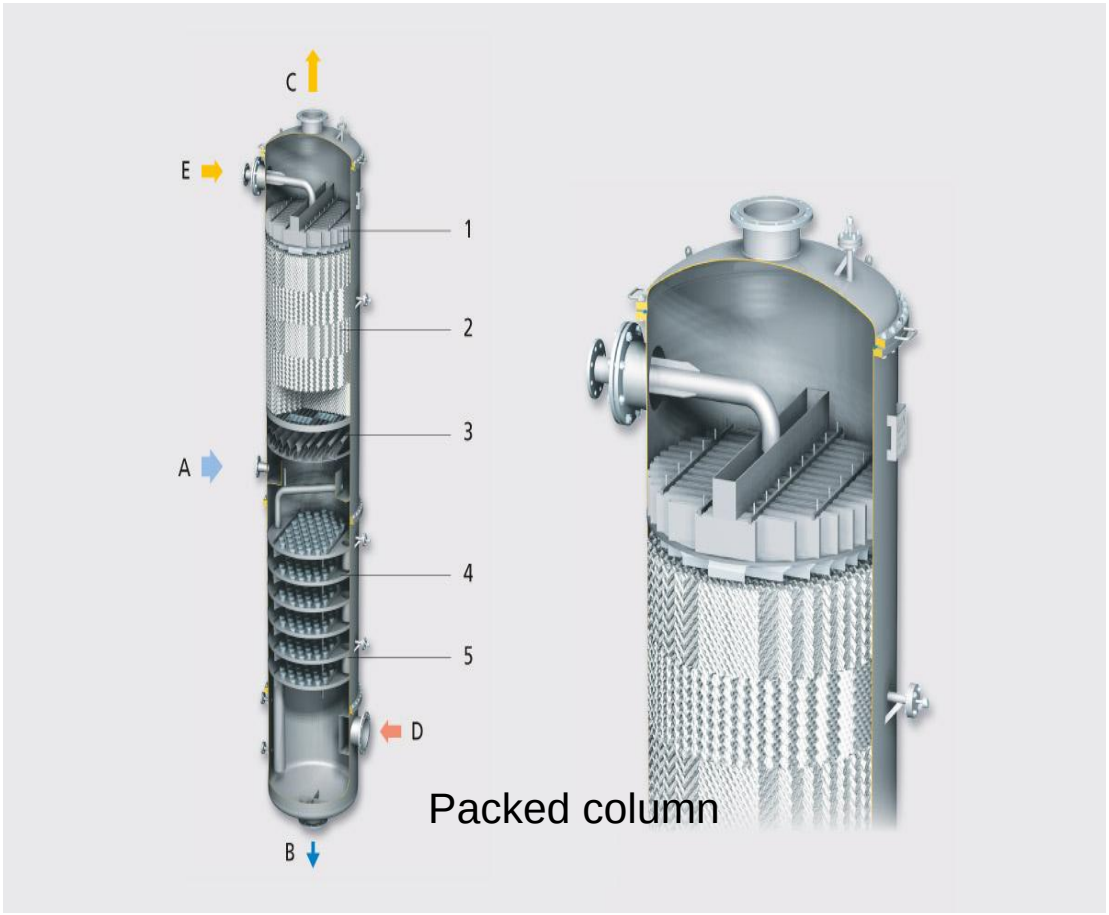
64	GB/T12459-2005	[illegible] 6"-4 C	2	20	0.8	1.6	
63		[illegible] ø88.9x4.37	2	20	11.66	23.32	L=1280
62	GB/T97.1-1985	[illegible] 30	4	100HV			
61	JGB901-1988	[illegible] M30x100	4	8.8			[illegible]
60	GB/T6170-2000	[illegible] M30	4	8			
59		[illegible] 360x230x30	4	Q235A	19.5	78	[illegible] M30 [illegible]
58		[illegible] ø219.1x6.35	1	0Cr18Ni9		20.62	L=619
57		[illegible] δ=10	3	0Cr18Ni9		19.5	
56		[illegible] ø406.4x9.53	1	0Cr18Ni9		176.2	L=1903
55	GB/T6170-2000	[illegible] M24	136	Q235A			
54	JB/T4707-2000	[illegible] M24x280-B	68	35	1	68	
53	04A/B-C01-02	[illegible]	1	0Cr18Ni9[illegible]		31.9	[illegible]
52	04A/B-C01-02	[illegible]	1	0Cr18Ni9[illegible]		26.6	[illegible]
51	JB/T4702-2000	[illegible] 2000-0.6 [illegible]	2	16MnR/0Cr18Ni9	[illegible]	2141.2	279.1/791.5
50		[illegible] ø26.7x2.87	8	0Cr18Ni9	0.3	2.4	L=155

HUITONG Chemical

Reg.No: 112120-ME00-S0053 Re

Tower nozzle orientation drawing





Packed column

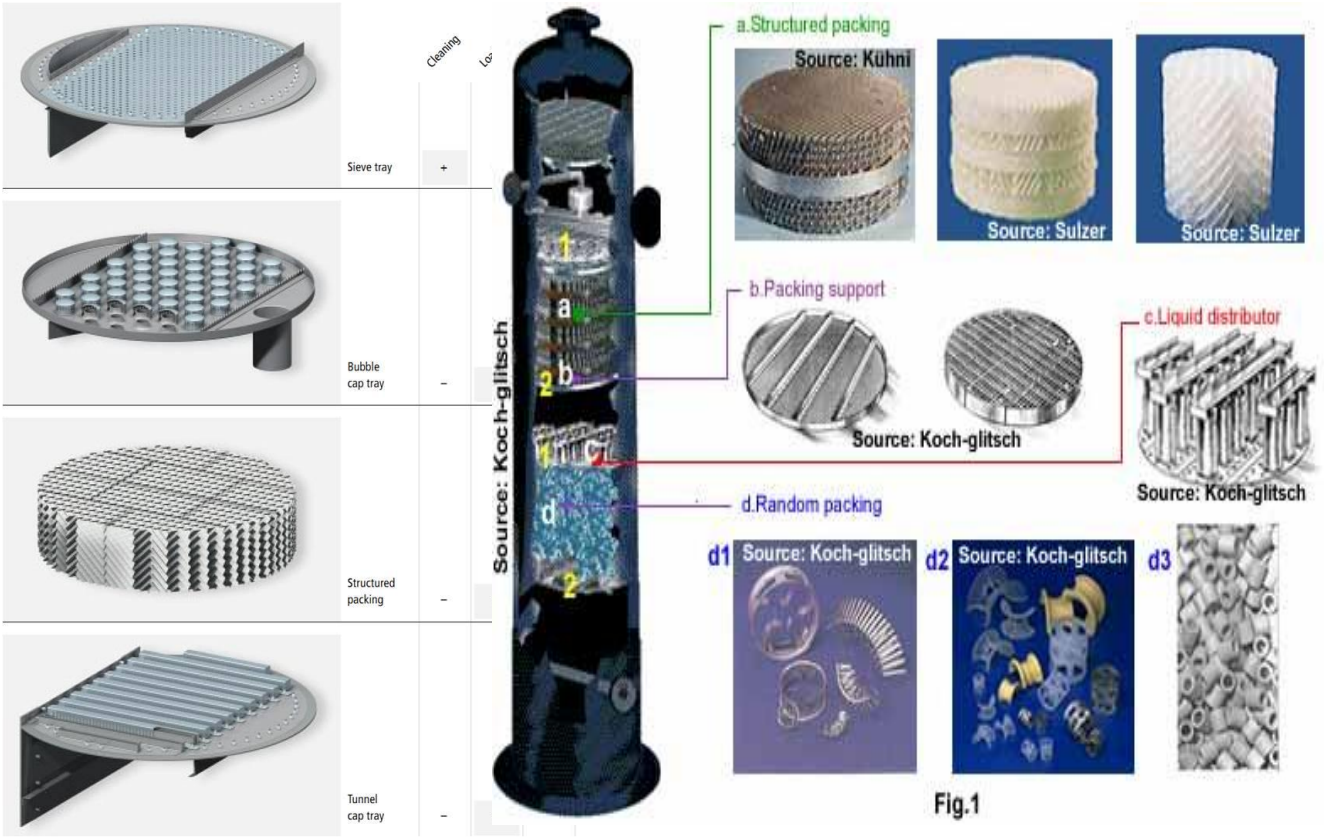


Fig.1

►3-2-B Separation Drums/vessels & scrubbers :

1-Equipment description:

This is a physical separation functional tank used for separation of vapors entrained in liquid flow.

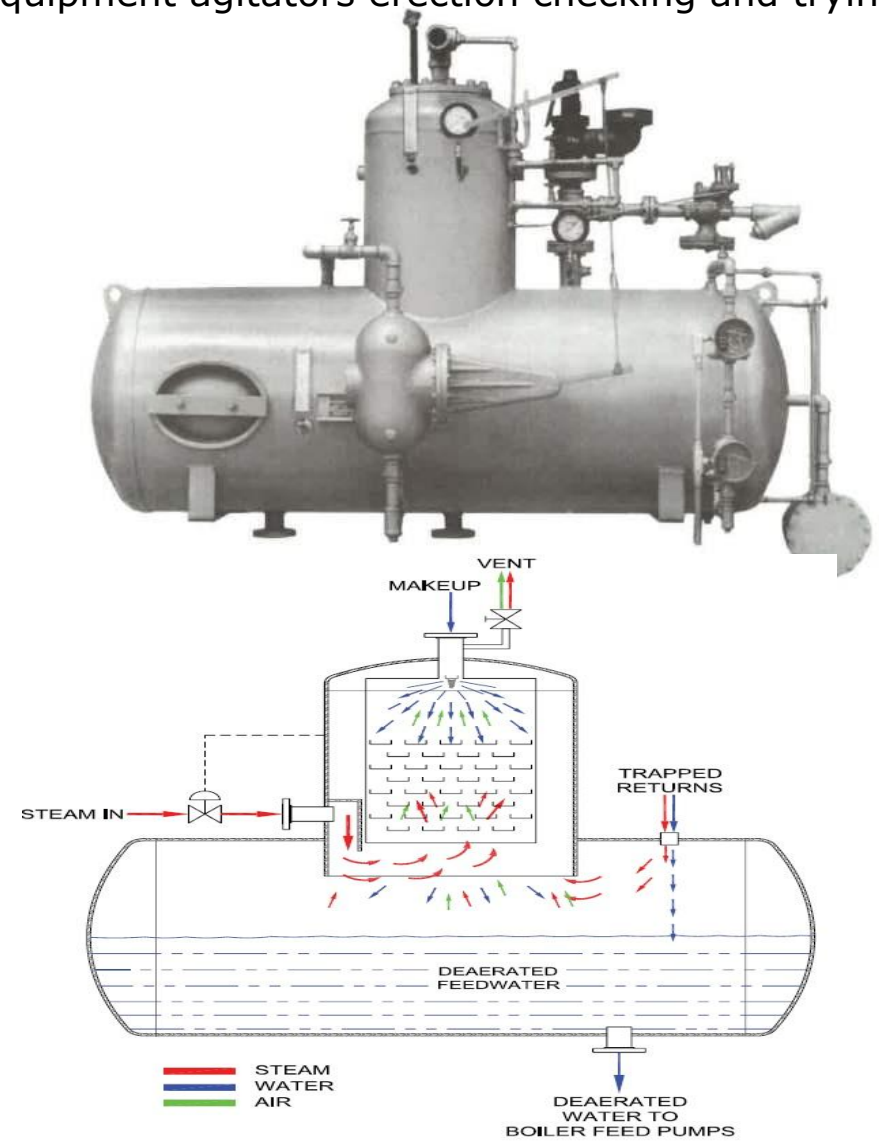
the **separation Scrubbers** are special types of the separation drums which is used the physical meaning of the pressure difference without using heating facility , also it is checked during erection phase in the same way we mention .

- It has a specific internal elements for the purpose of separation, like flash inlet baffles, anti-vortex bottom baffle, sometimes steam or hot vapor introduced from bottom for encouraging the separation levels, and internal over flow barrier may also be contented for some types of horizontal separation drums, also bottom coil with spreading nozzles may be there for heating and separation encouraging and sometimes the feed is introduced with barometric leg.

2-Pre-commissioning checking :

-Grouting for outer body progress checking report.
-Checking outer part typical to design and free of defects.
-Interiors checking typical to design and free of defects the fixing, assembling and cleaning are ok or some missed or defected parts.
-Inside cleaning inspection.
-Manholes boxing up with specified bolts and gaskets.
-Cold bolting with specified cold fitting torque.

-Some types of special designs for **separation scrubbers** has a rotating agitator for encouraging the separation whenever the mixture density is high or there is more suspended solids carried over from the process with the scrubber feed, this rotating part is erected after all erections and fabrications connected to the scrubber and its checking and reporting will be mentioned later for all equipment agitators erection checking and trying.



Another side of the separation special drums are the **-**

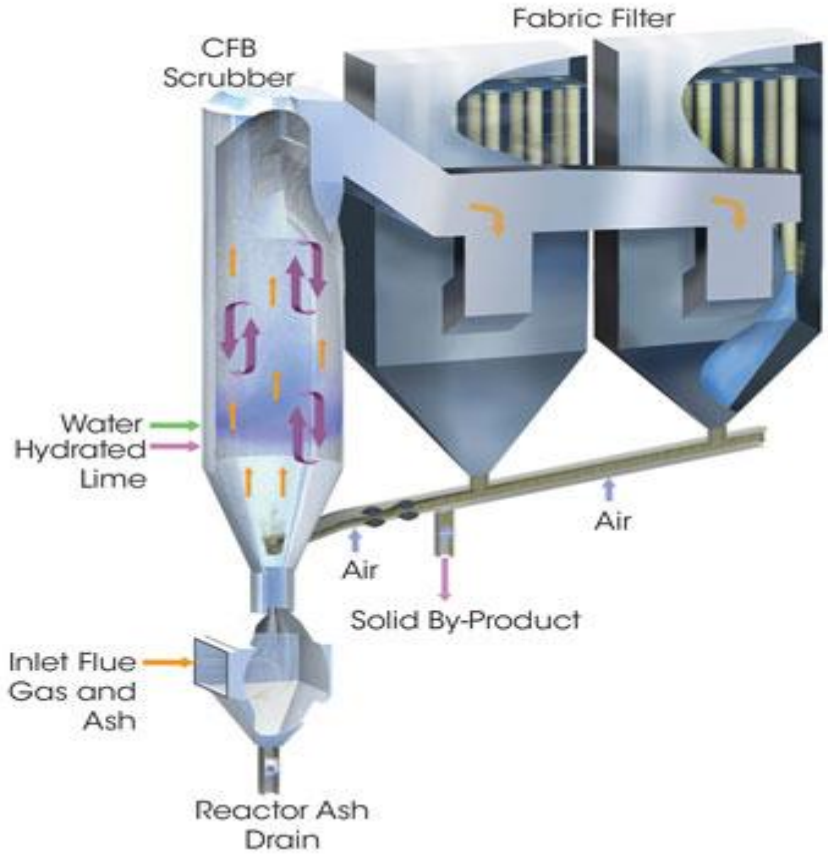
Separation scrapper it is used to separate solid particulates mainly from Air or vapor flow , using the meaning of water shower washing counter current with the Exhaust flow.

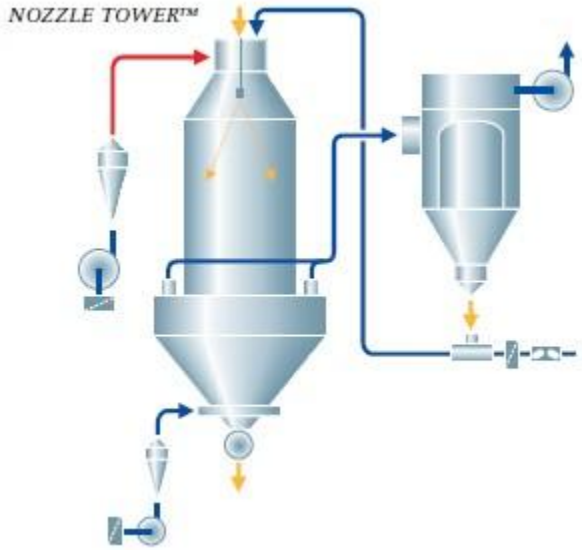
This separation scrappers may have some attached Cyclones for the post outlet Air flow cleaning from solids by the theory of the tangential flow for the cyclone wall which will produce an internal vortex like motion which promote solids settlement with the gravity effect down to the cyclone bottom then to dust collectors.

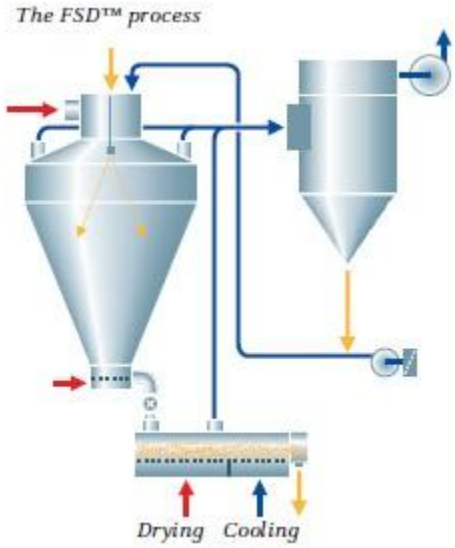
The mixture Air/dust flow to the scrapper then to cyclone is going on by using Induced air blowers or some time for special designs by using forced air blowers, and we will talk about the checking of the blower and its piping loops later in this course.

-Pre-commissioning checking :

-It is a hollow specific shape vessels, checking the body free of defects or damage.
-If there is internal filtration fixed bed,mesh, nozzles or supports, to be checked also ,to be checked also.
-check it is proper cleaned from inside.
-Boxing up activity following with proper bolting and gaskets.


Fabric Filter
CFB
Scrubber
Water
Hydrated
Lime
Air
Air
Solid By-Product
Inlet Flue
Gas and
Ash
Reactor Ash
Drain


NOZZLE TOWER™


The FSD™ process
Drying
Cooling

►3-2-C Filters and strainers:

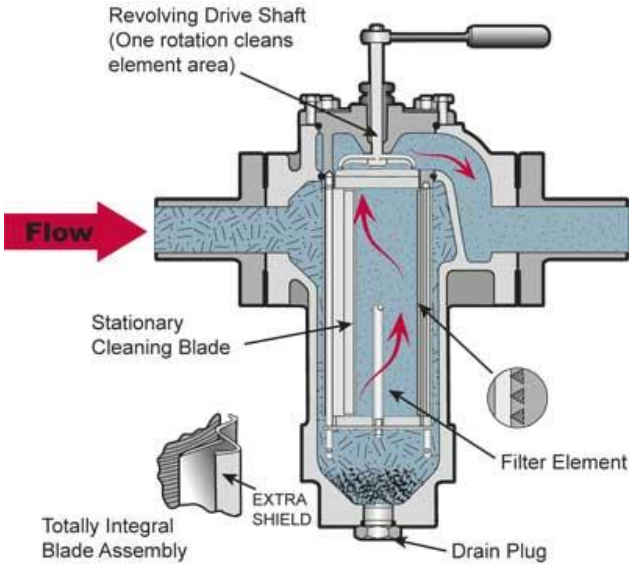
Equipment description:

are important static downstream equipment ,it is small to medium volumes but too much critical important, as the chocking of any of them may cause long process instability and lot of troubleshooting , they are erected usually sequenced with pumping or blowing systems , which means that also not process troubleshooting only is the problem but also machinery damaging probability increases.

In fabrication and erection stage the main things to check is firstly the nozzle orientation of the filter we have to assure that inlet and outlet are typically connected same as the drawings and assure nozzles not reversed, this thing , other thing is checking the filtration system interiors , checking that mesh is same size of design , and mesh not cut or defected, also checking that if there is candles inside that candles are properly erected not loosed , and candles not dirty and free of solids or greasy materials, so they have to be carefully handled with professionals.

●Filters has different types as per the flow capacity , the desired removing contaminants size , the physical properties of the flowing stream.

Filter outer part



candles

Basket

2- filters Pre-commissioning checking:

-Grouting and fixing to area ground with the proper nozzle orientation not to reverse the inlet and outlet directions.

-Outer body inspected no defects and typical to design,no nozzle bended or damaged. -It

must be correctly inspected that it is properly cleaned from inside , and free of strange fabrication materials like Arch welding rods which can damage the mesh, and results in harming the downstream equipment and process flow off-specification.
–Boxing up with proper bolts and gasket and cold specified fitting torque.

●Common Types of filters (Basket filters ,candle filters ,packed filters, Plate and frame pres filter, Paper membrane filter …etc.)

●Strainers are small filters is erected upstream for pump suction for also pump protecting and smooth operations like (y shape strainer and basket strainer….) Checked also by same way of filters checking and proper cleaning.

►3-2-D Heat Exchangers :

-Equipment description:

-Here we reached to one of the most critical elements of any petrochemicals or refinery plants ,as the main role for the heat exchanger is to play the transfer medium or the heat transporter between two different temperatures flowing streams,

Every stream has its own chemical specifications and physical properties , and the efficiency of heat exchanger is an important factor for controlling all downstream physical and chemical attitudes, the selectivity of the heat exchanger is depending on the flows properties like

-physical properties for every flow like(Flow capacity , Temperature , pressure ,density ,viscosity ,solid contaminants, Gas flow or liquid flow …etc)

-chemical properties like (tendency for corrosion, PH levels, scale formation abilities , toxicity ….,etc)

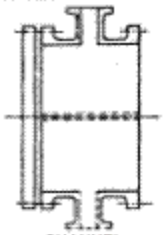
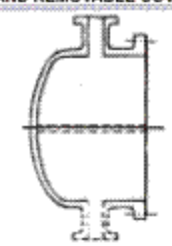
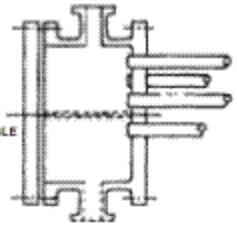
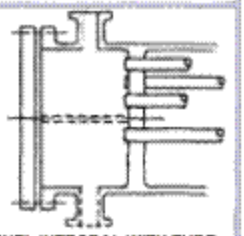
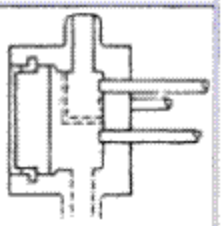
For every two flowing fluids has their variability for the pre-mentioned properties and as per the required process final out put the selectivity of the suitable heat exchanger will be optimized with taking in mind the cost of every selection and here we will mention some common types of heat exchangers and how to manage the erection and boxing up for every type:

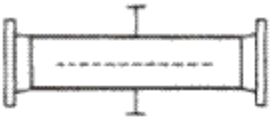
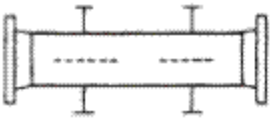
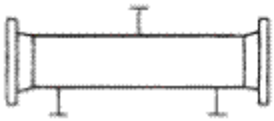
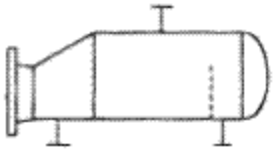
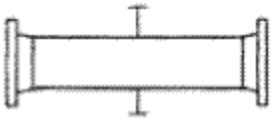
•Shell and Tube heat exchanger :

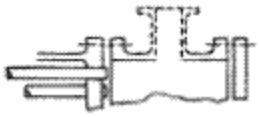
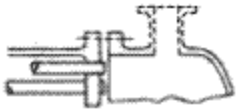
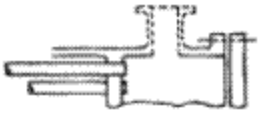
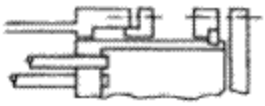
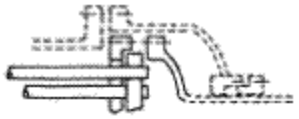
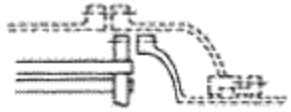
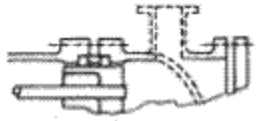
1-Equipment Description .: from the name it is obvious its main contents as the shell the outer part and commonly taking the flow of vapor content and tube taking the pure liquid flow , other it is one of the best choices as a its higher pressure capacity , moderate thermal performance higher than coil H.Ex and less than Plate H.Ex thermal performance.

-according to the service needed the volume of the shell , the shape of the shell head cover like (channel and removable covers , bonnet ,removable with the tube bundle) and also there is variable shapes of the shell itself like according to flow pass (single pass ,double pass ,split flow ,divided flow…etc)

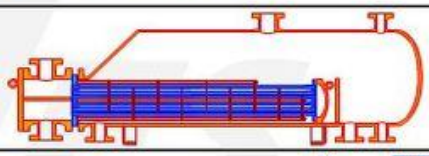
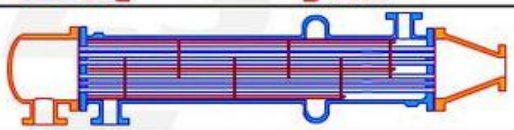
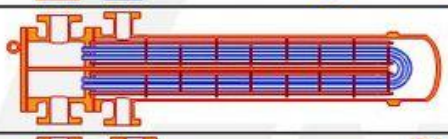
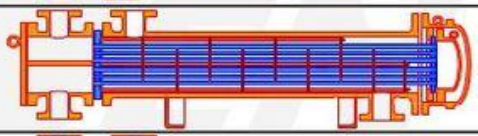
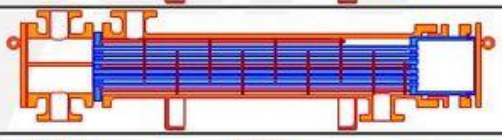
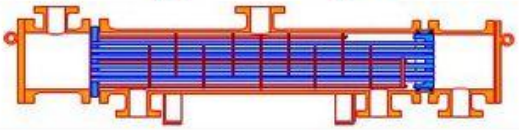
-then the selected shell type is transferred to the project site , our role to check if it is typical to the design , all nozzles are ok and no defections ,using the specified H.Ex drawing you can check its internal pass barriers ,

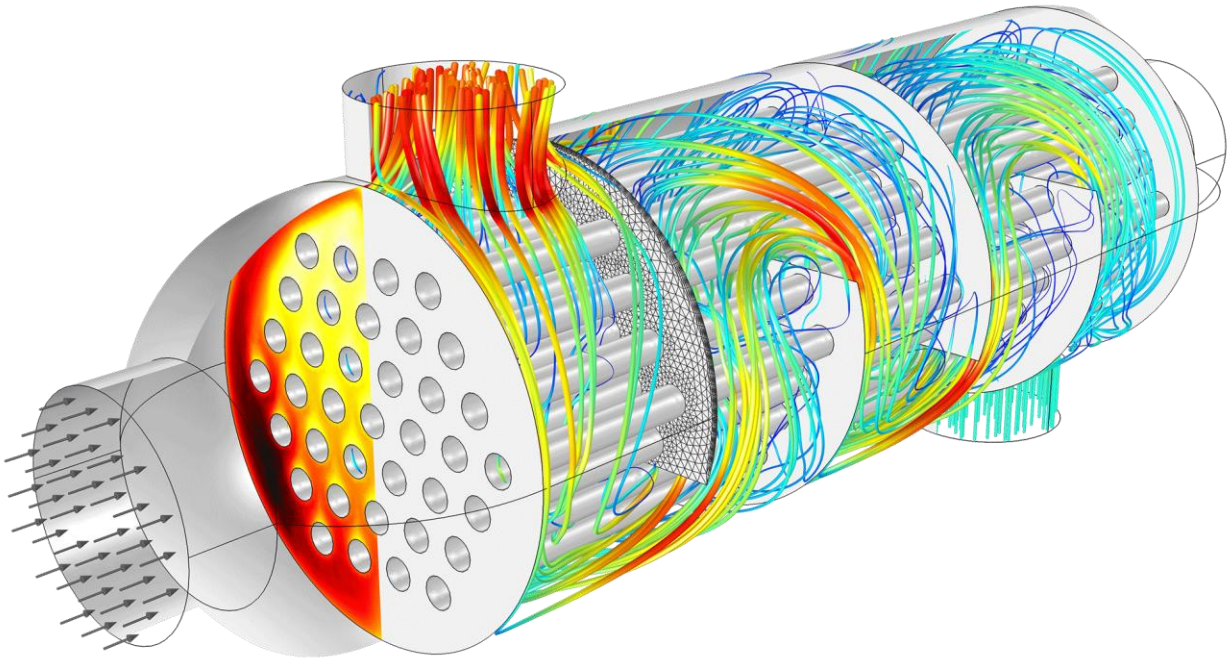
	FROND END STATIONARY HEAD TYPES
A	 CHANNEL AND REMOVABLE COVER
B	 BONNET (INTEGRAL COVER)
C	 CHANNEL INTEGRAL WITH TUBE-SHEET AND REMOVABLE COVER
N	 CHANNEL INTEGRAL WITH TUBE-SHEET AND REMOVABLE COVER
D	 SPECIAL HIGH PRESSURE CLOSURE

	SHILL TYPES
E	 ONE PASS SHELL
F	 TWO PASS SHELL WITH LONGITUDINAL BAFFLE
G	 SPLIT FLOW
H	 DOUBLE SPLIT FLOW
J	 DIVIDED FLOW
K	 KETTLE TYPE REBOILER
X	 CROSS FLOW

	READ END HEAD TYPES
L	 FIXED TUBESHEET LIKE "A" STATIONARY HEAD
M	 FIXED TUBESHEET LIKE "B" STATIONARY HEAD
N	 FIXED TUBESHEET LIKE "N" STATIONARY HEAD
P	 OUTSIDE PACKED FLOATING HEAD
S	 FLOATING HEAD WITH BASKING DEVICE
T	 PULL THROUGH FLOATING HEAD
U	 U-TUBE BUNDLE
W	 EXTERNALLY SEALED FLOATING TUBESHEET

POPULAR SHELL & TUBE HEAT EXCHANGER TYPES

	A K T	
	B E M	
	C F U	
	A E S	
	A E P	
	A J W	



Single-pass flow through the shell

-and also according to the service of the H.Ex applications the **Tube Bundle** shape is selected like(plain or finned internal tubes or finned external tubes) the tube sheet or the end connected plate to the tubes shape also is changed with the service it may be (fixed or float ,single or double) and

- the tubes number and its Outer and inner diameters OD,ID are also effective variable factor for the selectivity of the volume of the heat exchanger shell also ,where the Shell and tube metal alloys are very important for the heat transfer rate between the passing flows on both sides, and so giving wide range of heat exchanger optimization arrangement will defer also from service to another,

The arrangement of the tubes inside the shell has also different theories for assuring the best tube fixing and expected thermal expansion turning around ,

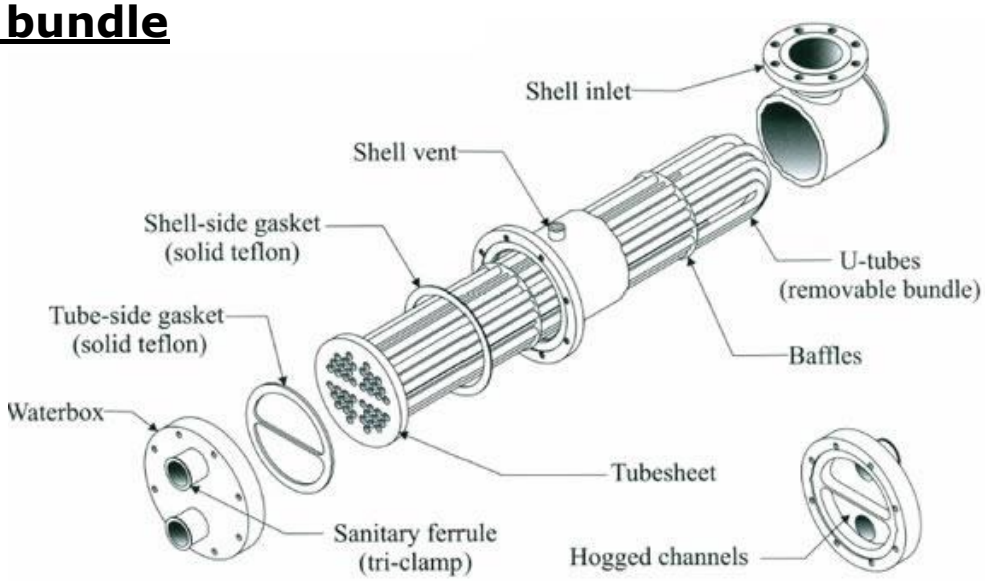
The Baffles are used as interior option for many purposes

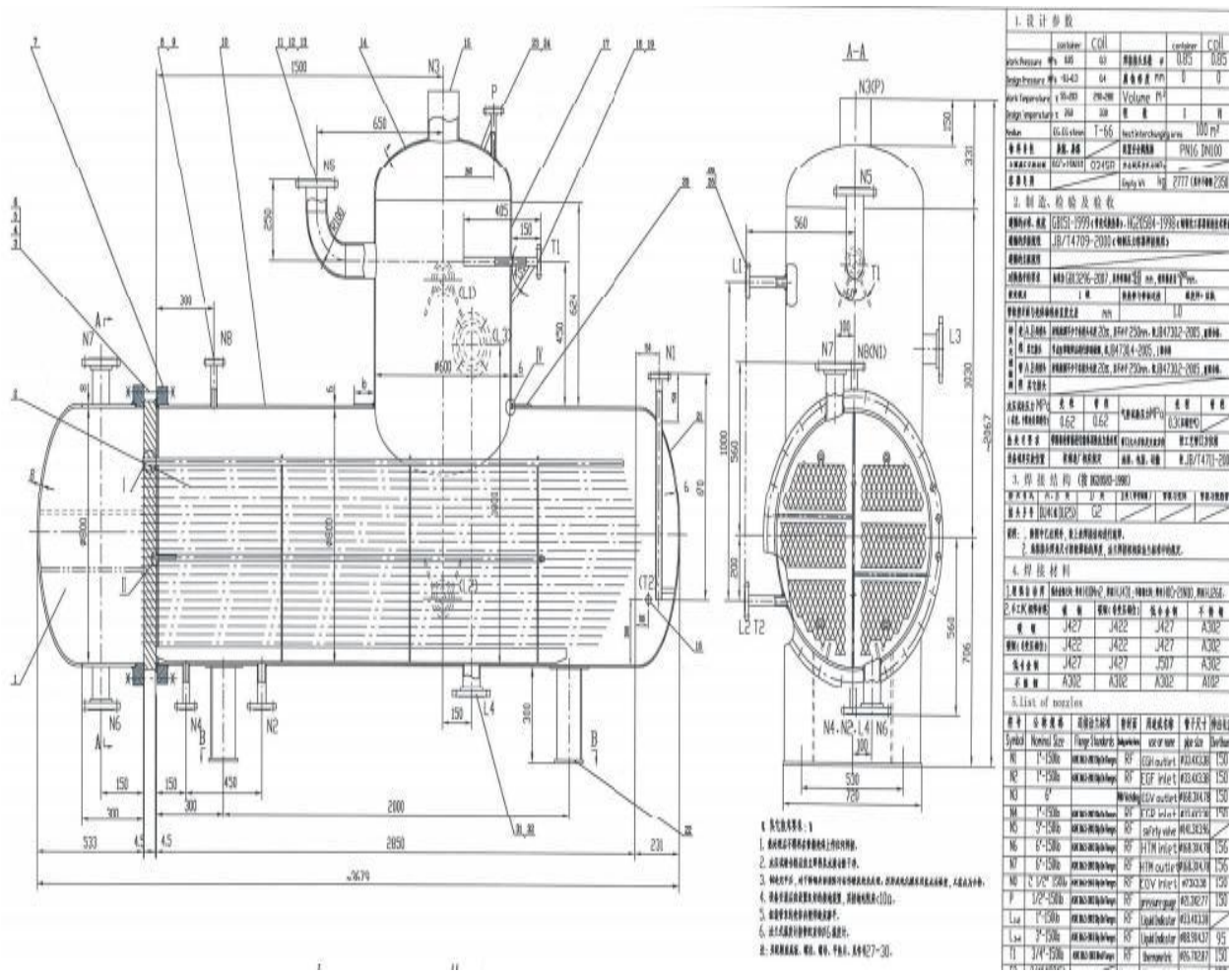
Like(fixing the tubes from excessive hammering or thermal expansion, baffles are also playing the role of Shell side flow turbulence providing as per residence time targeted for better flows convection/radiation, and this also will increase The Effectiveness (ϵ)of the heat exchanger as the

$$\epsilon = \frac{(\dot{M}\times Cp)hot\times(Tin-Tout)hot}{(\dot{M}\times Cp)cold\times(Tout-Tin)cold}$$

●As the service applied the tube bundles are transferred to the project site and carefully handled because any defection is high cost repairing , as per the design in the drawing check all the tube specifications and also the number of baffles also check the distance between them and its definite design in the drawings.

U-tube bundle





Shell & Tube evaporator drawing used for checking

●Pre-commissioning checking:

-The grouting of the shell check its nozzle orientation specially when the there is more than one heat exchanger connected in series or in parallel , and with the piping drawings you can define the flows pass type it is co-current in same direction or counter current .

-Check the contents Outer body shell and some evaporators has some sump coil extra interior this to be checked if found.

-Finally after inspecting the tube bundle didn’t defected during erection, you also assure the shell is clear from inside and no wastes or left fabrication parts, or any plastics inside this will affect the heat exchanger efficiency.

-Tube sheet and interior baffles assembly to be performed in proper way

-this to be primary cold bolting with the convenient bolts and proper head cover gasket and with the design proper cold fitting torque, for further hot bolting in the commissioning stage another hot fitting torque, and finally report that it is boxed up .

-Due to shell-tube expansion there is pass for the bottom grouting bolts.

-Earthing are applied to eliminate the static charge.

•Plate and frame Heat Exchanger:

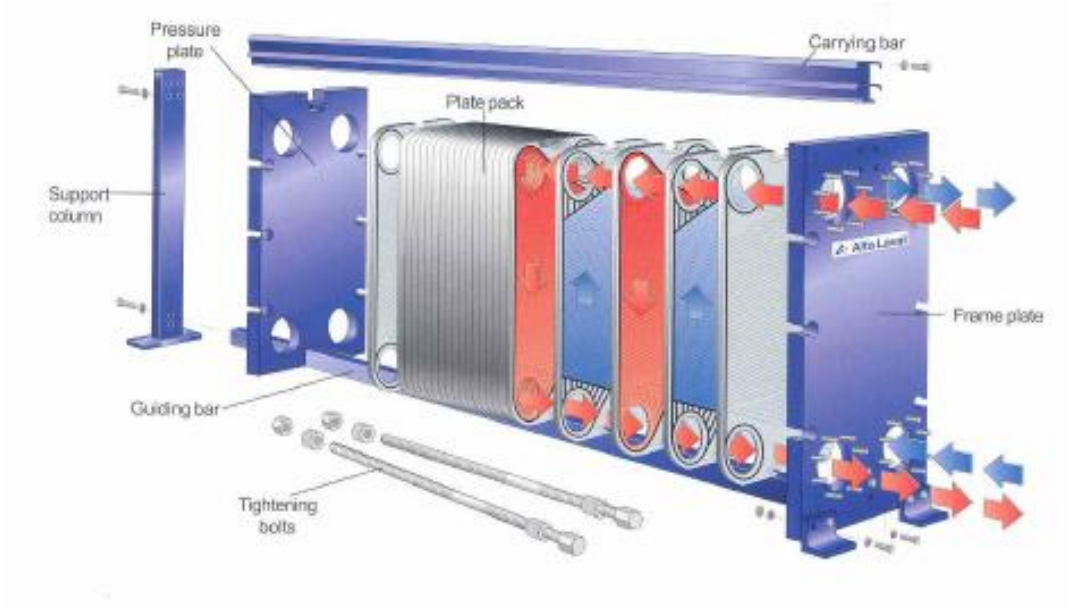
1-Equipement description:

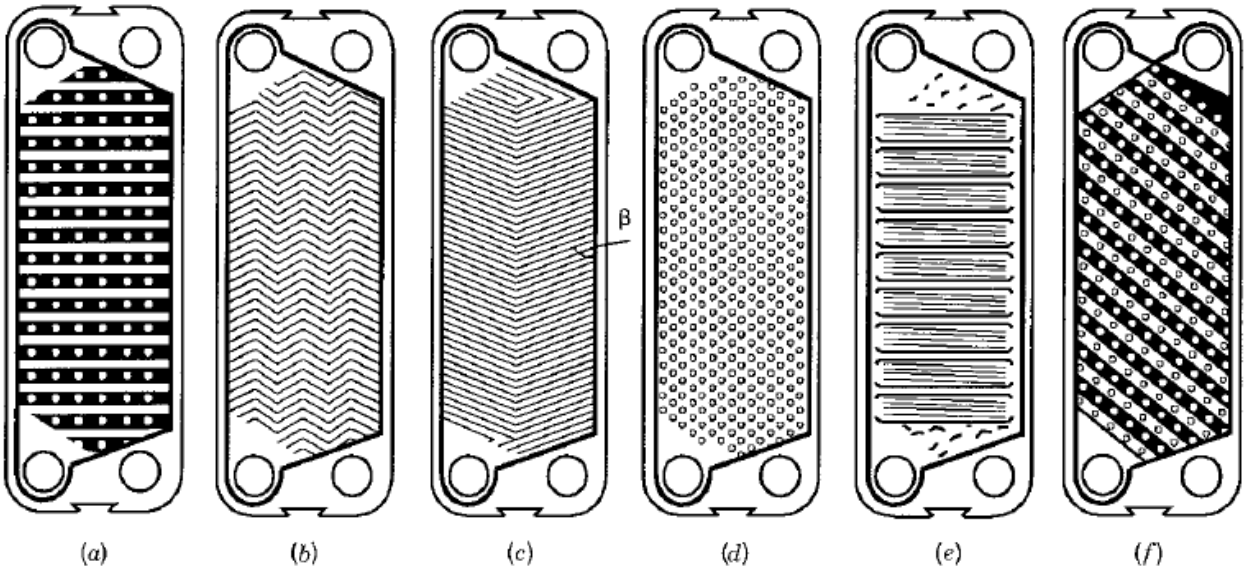
this is other popular type of heat exchangers

-it consists of:

A-outer metal fixed plate to the ground (The frame) from one side and other End metal free plate from other side .

B-in between these two main plates there are metal corrugated sheets with special design for better fluid/metal contact residence time. C-and in between the corrugated sheets there are special design rubber gaskets to control the flow pass through the corrugated plates. One pass for hot flow and other pass for cold flow.





Metal corrugated sheet and gasket

-This type of heat exchangers has some advantages like high heat transfer rate, and effectiveness, small volume, multi stream and multi pass configurations,….)

But it has some disadvantages like ,it isn't capable of high pressures. Also its gaskets are elongated due to opening and boxing up many times lead to outside leakage or internal flows mixing.

-Plate& frame Pre commissioning checking:

-The fixed frame grouting and the connection beam, to be checked balanced or not.

-all metal corrugated sheets to be properly checked no defections and number of sheets are the same for technology designed, neither more nor less, also the gaskets are carefully checked not damaged and not elongated and proper pass arranging of the gasket.

-improper gasket arrangement will lead to changing the flow pass and this will lead to flows mixing from both sides or closing the pass and prevent the flow.

-assure that only professional fitter will box up the heat exchanger because the excess tighten torque will damage the gasket, every P.H.Ex has its boxing up thickness and the tighten torque to be applied exactly to the determined thickness not more , not less .

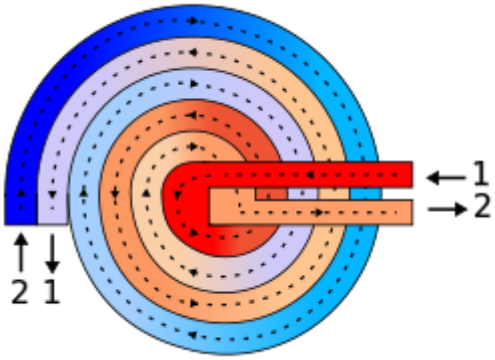
-assure all sheets are very clean , dust not allowed any way .

-electrical earthing for static charge elimination , checking.

•Spiral heat exchanger :

-Equipment Description:

-it is simply can be explained as folded two metal sheets on each other with tight spiral path between the two sheets , the two sheets are welded to each other from the tangential lines at the core or the heat exchanger and at the end of the sheet out surface of the Heat exchanger like shown:



Spiral Heat Exchanger

-It is giving very high contact area ,and enhance the heat transfer rate , but it is easily checked which promotes the process troubleshooting, so it is very important to provide suitable filters at both flow inlet to avoid this problem.

-it has inspection door, and it has whole face gasket, for proper flows paths isolation ,and mixing preventing.

-Spiral H.Ex Pre-commissioning checking:

-Check the heat exchanger dimensions are same as the design drawings.

-The outer body& nozzles, to be checked, free of defects.
-grouting to be properly and carefully performed with proper bolting, avoiding body or nozzles damage.

-Boxing up the inspection door after putting the attached gasket to be tightened with the proper bolts and the recommended tightening torque.
-the nozzles blind plastic cover to be put and keep closed till piping connection.

•Coil Heat Exchanger

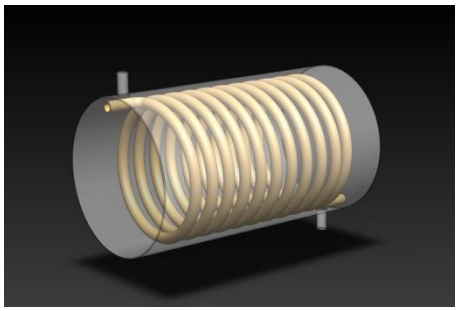
1-Equipment description:

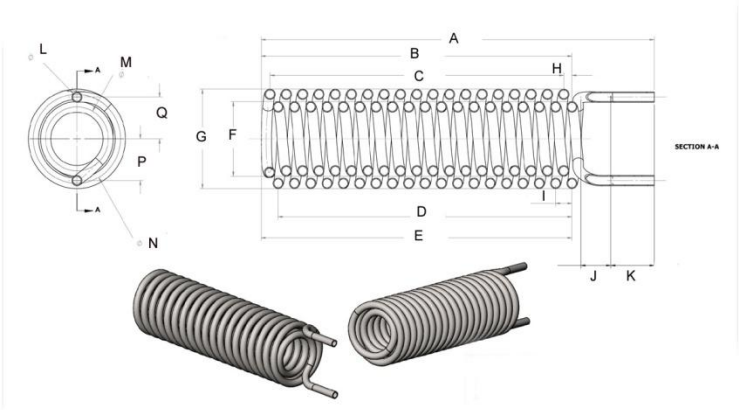
-It is another type of heat exchangers which has the capability of handling high pressures and wide temperature difference,

-it isn't expensive but provides poor thermal performance because of low surface area , which is modified for some application by making the coil of corrugated tube.

-It is widely used for heating specially in sups , like tower bottom sumps.

-the coil may be consists of double layers or more of the spring tube to provide more residence time if the flow inside the tube is passing fast with high pressure.





Next step using the specific drawing for checking like following:

2-Pre-commissioning checking:

-The coil can be tested before erection by using some outfit tools like blinding the inlet with nozzle fixed blind flange and blinding the outlet by a blind flange, then use air hose connection and pressurize the coil upto 1.5 times of the operating pressure , and check the pressure drop after some time , if the is any drop so check by soap water mixture the coil and if it isn't possible you can pressurize by water, this step only to assure that the coil body isn't defected during transferring to the project site or it has any manufacturing defections.

- The coil is erected to the sump of the tank or the tower very carefully because it is only a hollow tube which can be easily buckled or damaged if it is hit to other solid bodies.

-After erection cover the coil inlet and outlet till it is connected to the post fabricated pipes to keep it clean.

►3-2-E Air cooled condenser (H.Ex.):

-Equipment description:

-Usually this type of condenser is applied for large produced vapor from the process , which need a large surface area for providing better cooling and condensing for the desired capacity.

- It consists of a number of finned tubes with special design for increasing the surface area and allowing better contact between the air and the tubes surface.

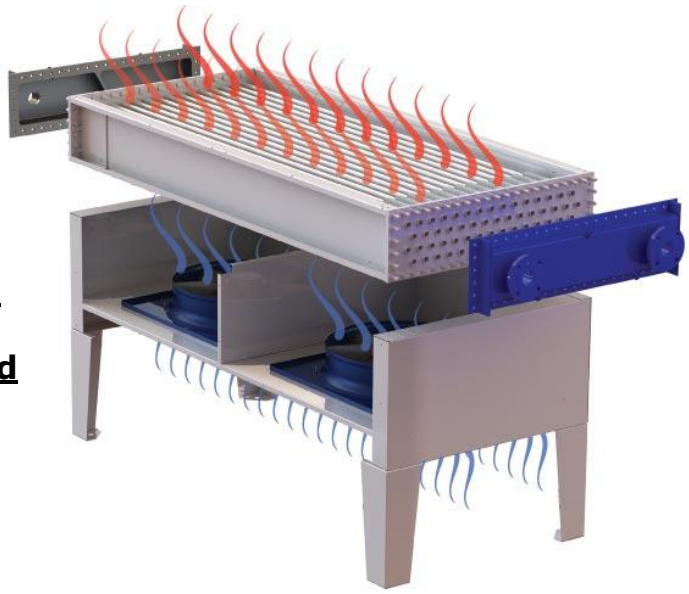
-Tubes has inlet & outlet tube sheets with defined number of openings ,and this sheets are covered by a head cover with single path for inlet vapors , and same also the outlet condensate and non condensable cooled gases.

-For the cooling process motorized air fans are used for blowing the cooled ambient air passing in between the finned tube which remove a large quantity of heat very fast and condense the process vapors into condensed liquid.

- The air fans are mounted at the top or at the bottom or at any side of the condenser body (induced flow or forced flow) of the air towards the finned tube bundles and this is applied as per targeted cooling and vapors mass flow rate , and ambient area air temperature.

Air cooled condenser

Fans bottom mounted



Finned Tubes bundle

-Pre-commissioning Checking:

-Grouting of the condenser body structure firstly to the ground and bolted properly, check ok.

-then check the tube bundle status before erection, if ok follow the erection activity for safe lifting, and check the body after the erection is ok, it is recommended not to walk on the finned tubes because it is very weak and easily bended , and this will affect the bundle efficiency .

-the fans are erected as a final step and we will discuss fans in the rotating equipment chapter.

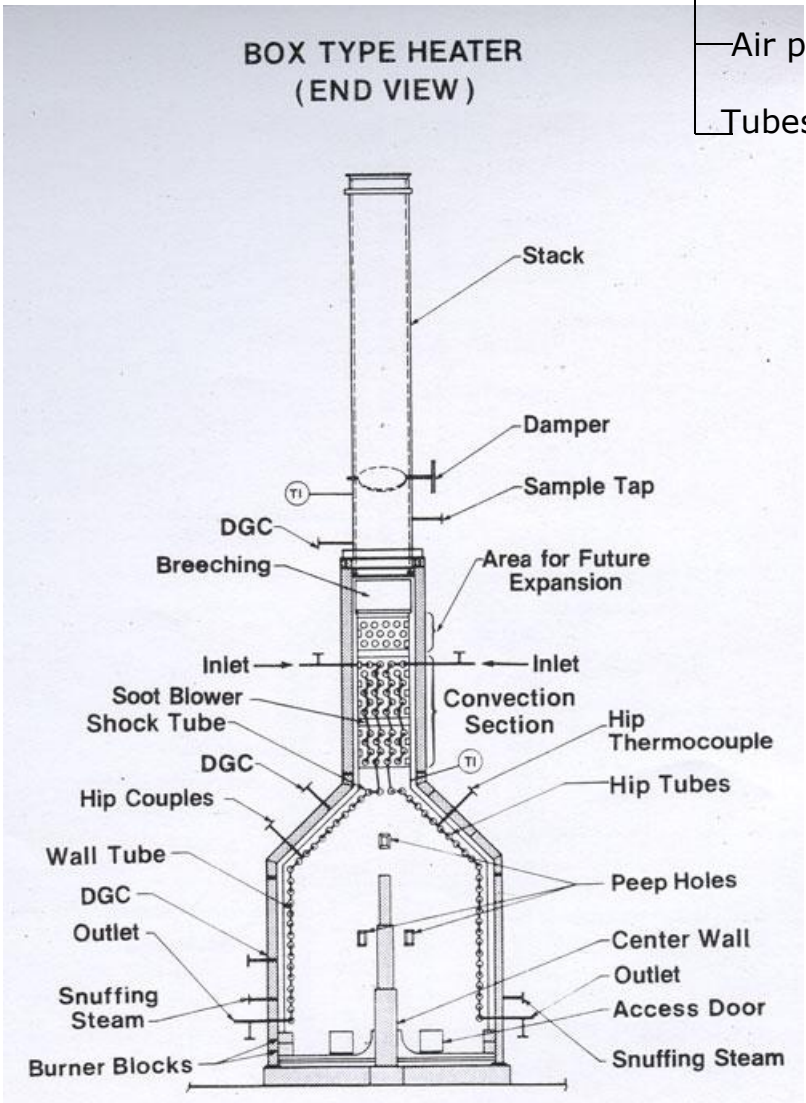
-The tube bundle heads inlet and out let are erected and kept closed till fabricated pipes connected.

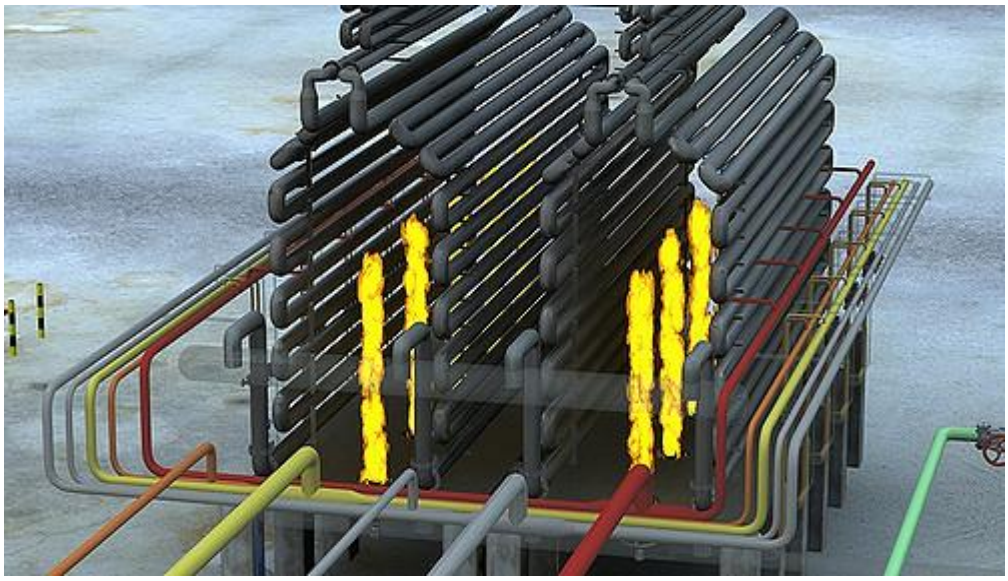
•3-2-F Fired Heaters Furnaces:

1 Equipment description:

-most of furnaces consist of

- Burner
- Radiant Section
- Shield Section(bridgewall)
- Convection Section
- Flue stack
- Damper
- Air preheat system
- Tubes, Pipes &fittings



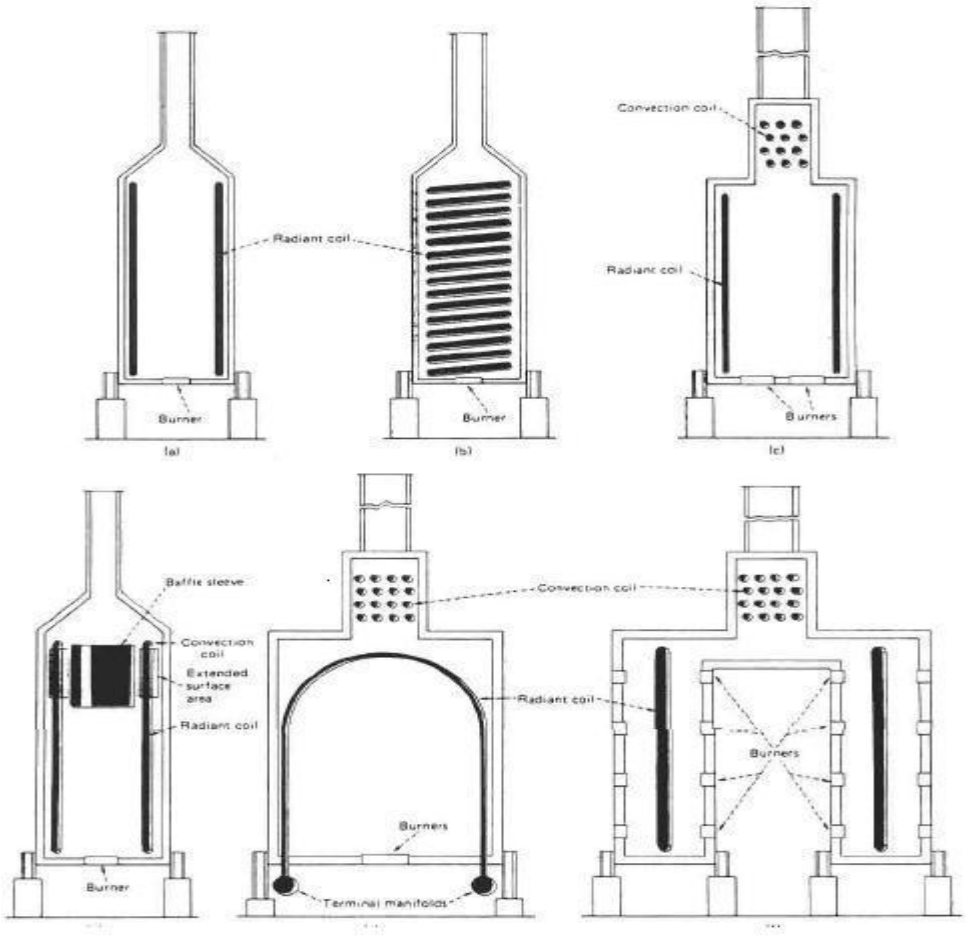


-also there is many shapes of the fired heaters

Like

- -Vertical cylindrical all radiant
- -Vertical cylindrical helical coil
- -Vertical cylindrical with cross flow convection
- -Vertical cylindrical with integral convection
- -Arbor type
- -Vertical tube single –raw with double fired

As shown in this figure



-Fired heaters furnaces are such a big heating facility uses the direct firing for heating the fluid (crude oil) flowing in the tube or the coil which , where the fire is at the center of the furnace and the tube is turning around with different shapes and different technologies ,the flame width and length is totally controlling the targeted heating level for circulated oil in the tube side,

and the flame size is the scientifically depends upon the flows of burnt fuel and the combustion air percentage , and this mixture is controlled by complicated system of number Temperature

sensors along the furnace which is cascaded with the control valves of the combustion mixture streams fed to the Burner.

The burner is the actual furnace mind which is adjusting its flow according to the oil-tube side flow rate. Which is providing a wide range of heating .

-As every part of the furnace is treated as critical part, and must properly understood to be aware of the defection, damaging, or improper erection risks on the process ,the safety and the environment.

-Burner is one critical side of this huge equipment ,as the burning started with definite sequence and then continued by another sequence, the burner technologies are more , but the convenient one is determined by the process conditions as the mixture to be burned is different from process to another.

The burner consists of primary start firing and secondary continuous flaming. The first start firing need the fire triangle to be achieved (spark, air and flammable material), and as per the fired flammable material if it is gas or liquid the shape of the design will differ, because the mixture contents to the burner will be different as the mixture of (Natural gas with secondary, primary air and off gas feed to the burner) will differ from (Diesel

mixture with the supplied air and process off-gas flow to the burner).

-The ignition and flaming sequences of the burner is the main issue to be professionally and strictly adjusted as the erection of the burner will affect its performance directly so mounting .

-here we will talk about the furnace pre-commissioning, and later we will explain its commissioning and startup.

1-Furnace parts Pre-commissioning checking:

-Furnace outer body is almost transferred fabricated to the project site, so as a member of the commissioning team , you carefully check the outer body& its nozzles as per design free of defects or damaging.

-and same thing to be done after the outer body grouting, if there is any damage pointed out this is better to be directly reported to higher management, this is so critical.

-The outer body of the furnace has many erected small globe valve for giving the variety options tubes draining these all valves to be checked, that its direction is properly fabricated , because globe valve can't be reversed and this type of valve will be further explained at piping fabrications checking.

-furnace body always has many sight glasses for flame and interior checking, and time to time flame inspection if there is any leakage or incomplete combustion and smoke generating., these sight glasses not to be erected unless the major fabrications around the furnace implemented , to keep it away from breaking.

-after outer body checking the interiors also to be checked if possible , as inspecting the tube inside the furnace free of defects ,cracks or buckling and its supporting to be checked also, try to keep the tube inlet and outlet opening is properly closed to keep it clean till piping fabrications.

thermo-wells if found to be checked also and damper status to be checked if it is fabricated inside the way to flue line.

-then the burner to be mounted on its base as per whatever on the top or at the bottom, very carefully and if any metal gaskets included also to be checked and properly erected then check all its connected nozzles as per design and free of defects, the if grouted properly ,so cold bolting to be proceeded with the proper bolt types typical to the designed, if any bolts missed so this will make a problem don't proceed to next step without proper bolting.
-the primary air blowers to be proper grouted then check the ducts of the air preheating system and heat inter-change chamber.
-Check the flue gas stack proper grouted and oriented typical to design drawings.

-follow the ducts fabrication progress of the flue gas line to the flue gas blower then to the stack is proper fabricated and no buckling or body defections.
-Cleaning the furnace properly from inside, then boxing up the blinds and manholes with the proper bolts , and with the specified cold bolting torque.

▶3-2-G Reactors:

1-Equipment Explanation:

- Reactors are a medium to big size pressurized vessels, with specific external and internal design and details which differs with the application chemical reaction attitude.

-Reactors have many different types for example:

- As per feed to the reactor and the reactants conversion: (Batch Reactors, Continuous reactors and Plug reactor).
- As per reaction thermal attitude: (Exothermal Reaction with cooling system ,or Indo-thermal Reaction with heating system)
- As Per reaction medium : (gas phase in fluidized bed or fixed bed)- (liquid phase with agitation or without)

-In Petrochemicals field the main reaction is the polymerization reaction and as per the polymer final product chain length and targeted conversion the selectivity of the reactor will differ from polymer to another.

- The Polymerization reaction attitude will catastrophically fluctuate if any part of the reactor failed or defected , so the reactor all parts to be deeply studied and understood before going for any of project phases.

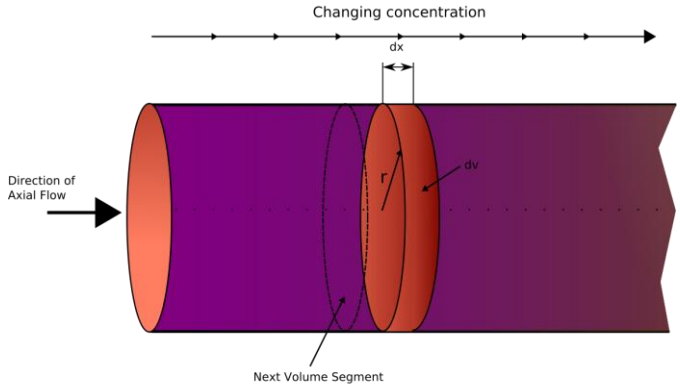
-The polymerization reaction as we mentioned is exothermal or indo-thermal and as per this process quantity of heat need to be removed if exothermal or heat to be added if indo thermal , the internal and external fabricated parts of the reactor will vary.

-some reactors bodies are equipped with:

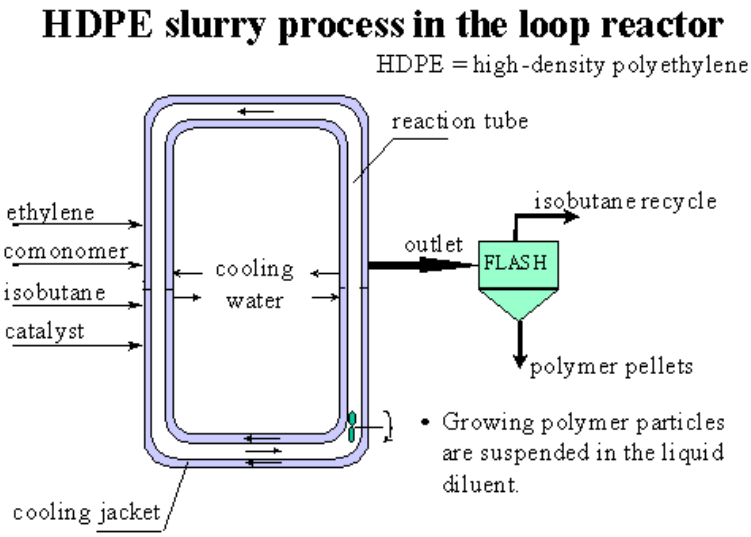
1. external jacket only fit the body,
2. and other type are equipped with internal coil or tube bundle only supported to the body
3. and for some polymerization reactions the reactor has both facilities outer jacket and inner coil.
4. Last type are the reactors which aren't provided by ay heating or cooling facilities , they are only uses the preheating or cooling systems for the reactants streams to the reactor.
5. Top mounted agitator.
6. Bottom mounted agitator.
7. Internal barrier for feed reactant row going tangential to the body internal surface
8. For Stirred reactors some applications wall baffles are applied

Like this shown figures:

Jacketed, stirring reactor



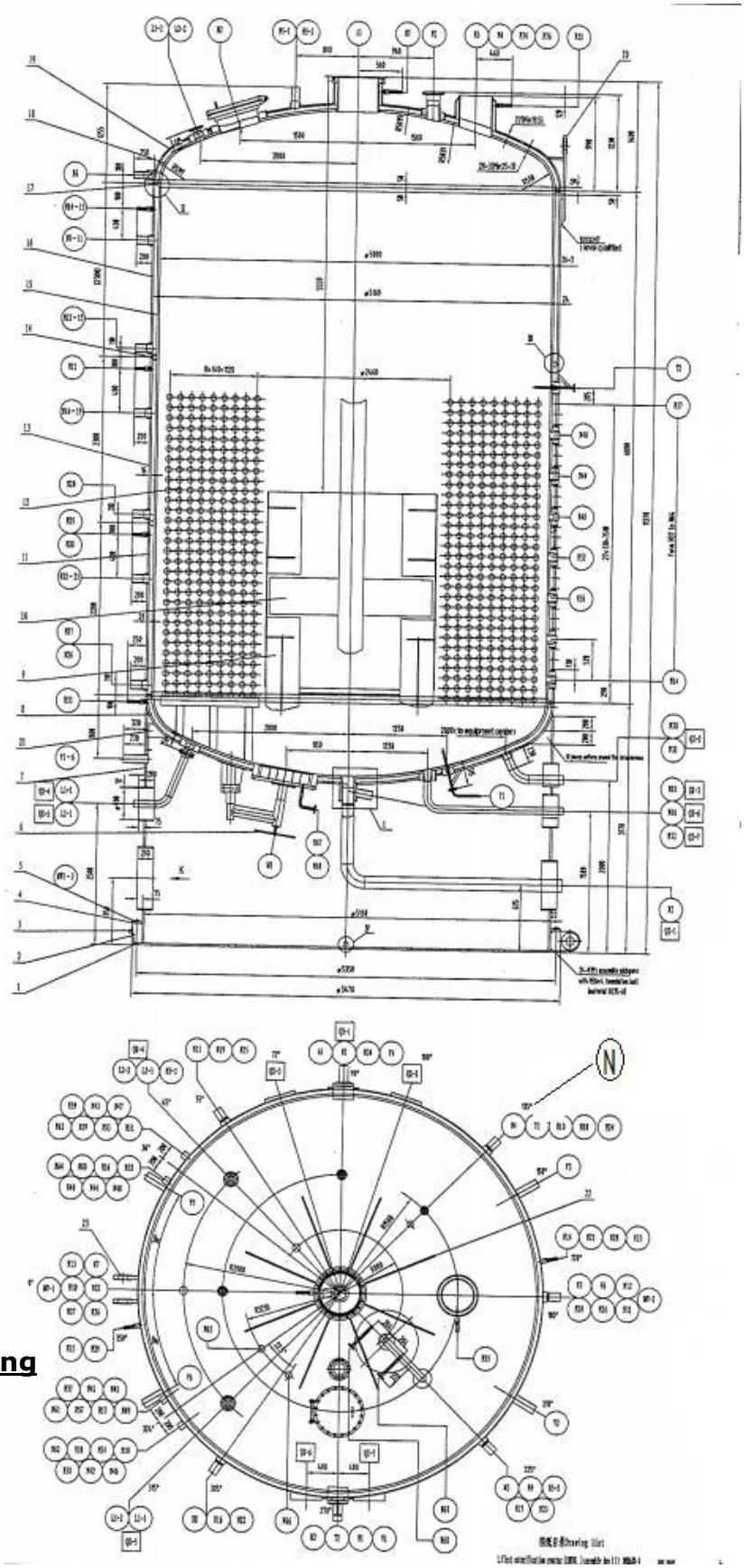
Plug flow Reactor



next step is using the specified Equipment layout and nozzle orientation drawing for checking the reactor parts, like this examples.

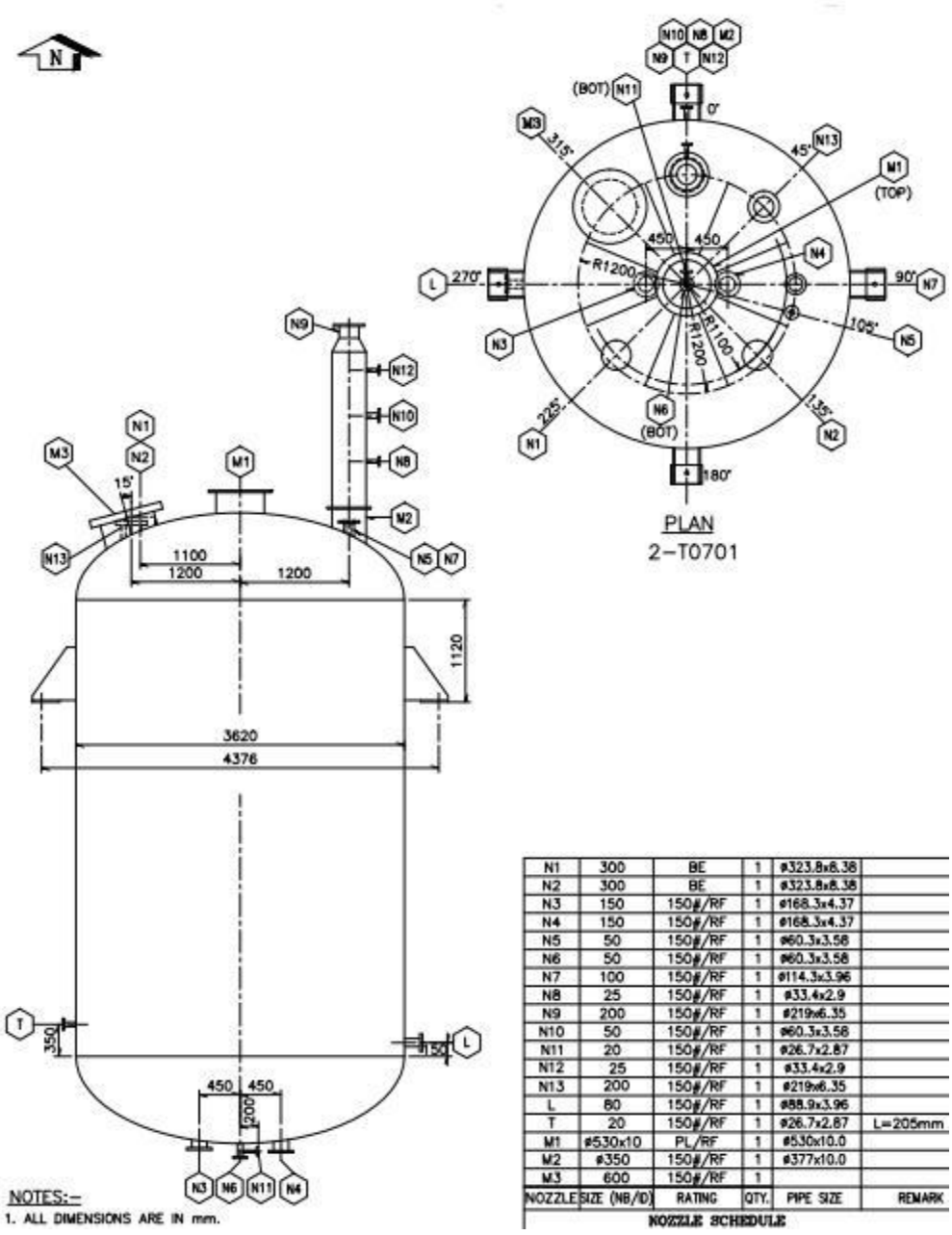
2-Reactor Pre-commissioning checking:

- Reactor outer body checking and internal fixed components, to be revised before lifting and grouting to be same dimensions and specifications as per design.
- The mounting and grouting of the reactor body to be proceeded by very accurate nozzle orientation, not to complicate the post piping fabrications.
- Then reactor outer &inner fixed parts checking after mounted into the plant building , free of any nozzles damage and no any buckling occurred to the body.
- Fixing by proper specified bolts for the body of the reactor to the building to be carried out by proper cold bolting torque, and if the reactor body will be heated in the commissioning stage so further hot bolting to be carried out later.
- Checking the internal parts like wall baffles , barriers or inside coil if there to be checked and any defects to be pointed out in report for managerial level.
- If the reactor has specific agitator (rotating part this to be checked in next rotating equipment fixing and pre-commissioning part) .



Layout drawing

for reactor



NOZZLE	SIZE (NB/D)	RATING	QTY.	PIPE SIZE	REMARK
N1	300	BE	1	ø323.8x8.38	
N2	300	BE	1	ø323.8x8.38	
N3	150	150#/RF	1	ø168.3x4.37	
N4	150	150#/RF	1	ø168.3x4.37	
N5	50	150#/RF	1	ø60.3x3.58	
N6	50	150#/RF	1	ø60.3x3.58	
N7	100	150#/RF	1	ø114.3x3.96	
N8	25	150#/RF	1	ø33.4x2.9	
N9	200	150#/RF	1	ø219x6.35	
N10	50	150#/RF	1	ø60.3x3.58	
N11	20	150#/RF	1	ø26.7x2.87	
N12	25	150#/RF	1	ø33.4x2.9	
N13	200	150#/RF	1	ø219x6.35	
L	80	150#/RF	1	ø88.9x3.96	
T	20	150#/RF	1	ø26.7x2.87	L=205mm
M1	ø530x10	PL/RF	1	ø530x10.0	
M2	ø350	150#/RF	1	ø377x10.0	
M3	600	150#/RF	1		

NOZZLE SCHEDULE

Nozzle orientation drawing for reactor

3-3 Rotating Equipments Precommissioning:

-Summary:

►-Rotating Equipments is the most critical part of any Petrochemical plant or any refinery, as it is considered as the heart of the plant which is derived by electrical motor to facilitate the transferring or the agitation or any other mechanical moving application for the materials around the different equipments through the units of the plant.

►- Rotating means motion, and to get the required application motion the equipment which will transfer the motion must be connected to electrical motor, with suitable horsepower and suitable rpm (rotation per minute) sufficient for the service required and more ,not to be over loaded .

►-Rotating Equipment isn't free to move anywhere or to any rotating direction, all rotating equipments have fixed static portions, and other rotating parts, and other in between bearings isolating the rotating and static part from each other, to protect both sides from thermal or frictional damaging during running.

►-The protection methods for the rotating parts are more and different but its selectivity depends on the required service conditions ,like cooling and isolating mechanical seals which are widely used for this purpose for many applications , every application has its proper optimized mechanical seal plan as per type of chemical an physical conditions of the service flow material.

►3-3-A Pumps Precommissioning:

1-Equipment Explanation:

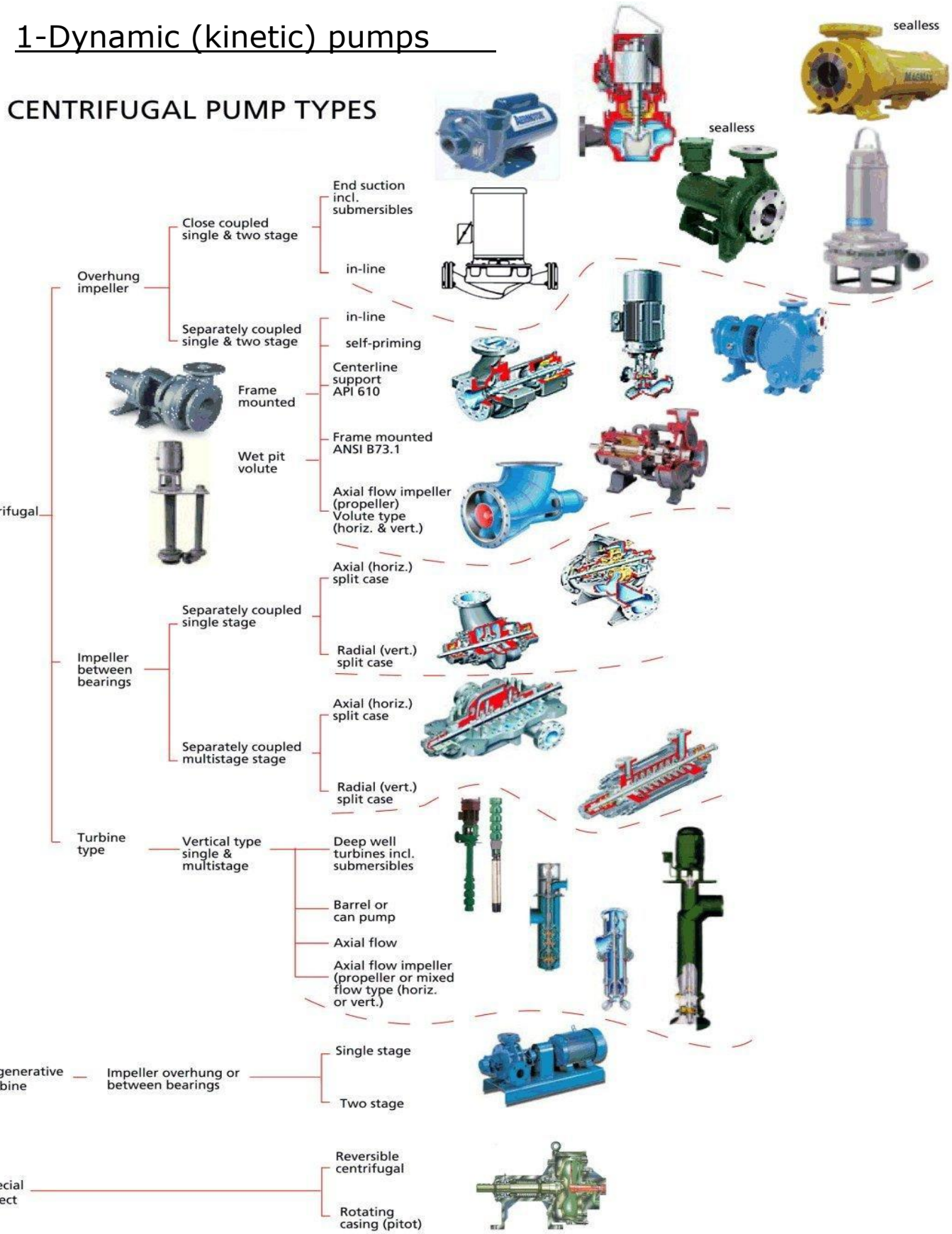
-First popular rotating equipment in any plant, usually pumps are used mainly to move the liquid from a point to another point where the head difference between the two points will not permit the fluid to flow without the help of energy source.

-Pumps type varies in the design according to varying in the required functions, where there are some main factors which help in suitable pump type selecting:

- The type of liquid to be transferred and according to its physical (density, viscosity…) and chemical(corrosiveness , toxicity, flammability, tendency to coagulate, its bubbling& dew points……..).
- The operation conditions variables (Pressure and head difference, Temperature ,time of running, the minimum and maximum required flow rates , also the minimum and maximum available suction head)
- The grouting position inside closed area in the plant , or it will serve outside the plant in open atmosphere

►►-Common Types of pumps:

1-Dynamic (kinetic) pumps



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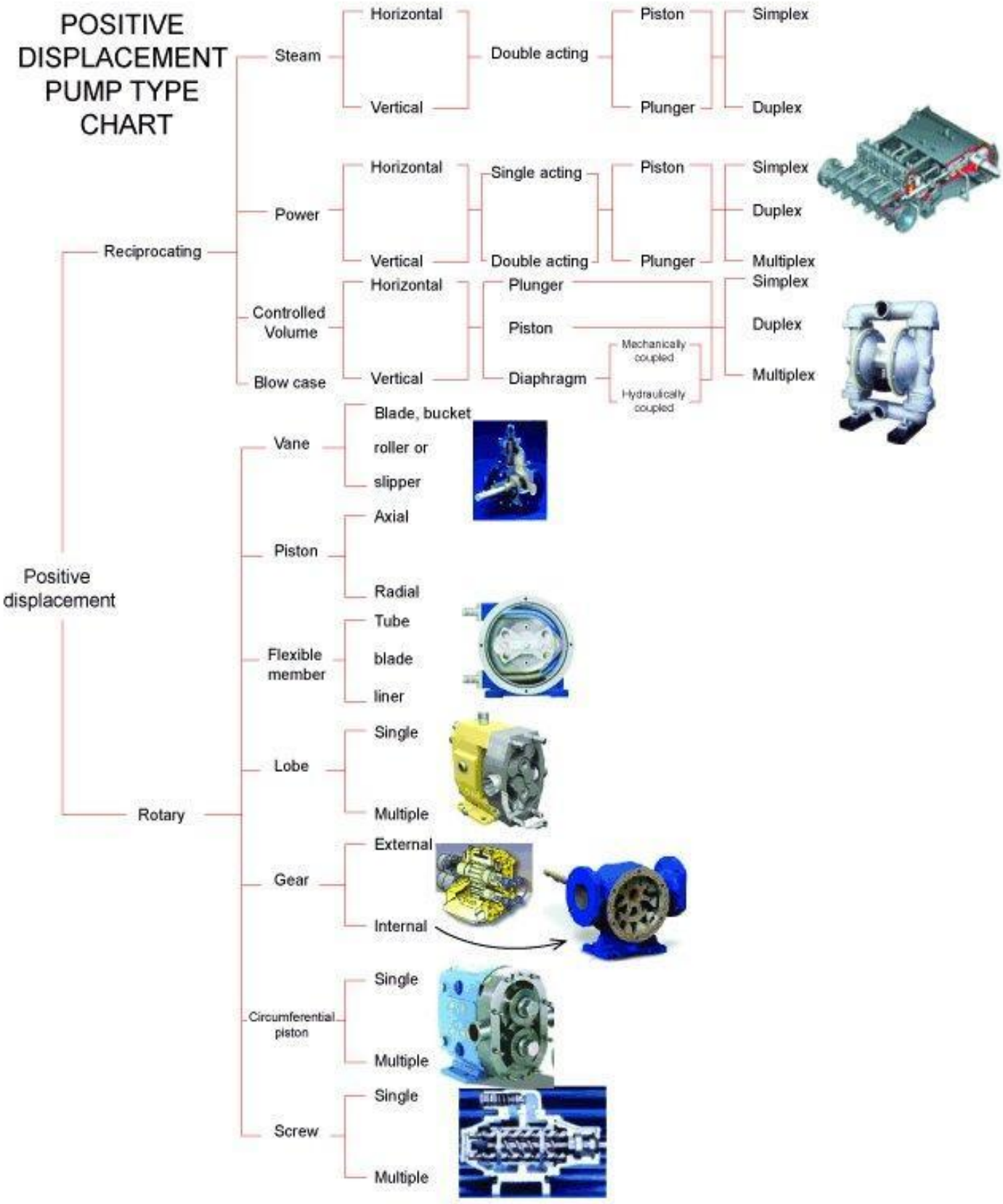

POSITIVE DISPLACEMENT PUMP TYPE CHART
Positive displacement
Reciprocating
Steam
Horizontal
Vertical
Double acting
Piston
Plunger
Simplex
Duplex
Power
Horizontal
Vertical
Single acting
Double acting
Piston
Plunger
Simplex
Duplex
Multiplex
Controlled Volume
Blow case
Horizontal
Vertical
Plunger
Piston
Diaphragm
Mechanically coupled
Hydraulically coupled
Simplex
Duplex
Multiplex
Rotary
Vane
Blade, bucket
roller or
slipper
Piston
Axial
Radial
Flexible member
Tube
blade
liner
Lobe
Single
Multiple
Gear
External
Internal
Circumferential piston
Single
Multiple
Screw
Single
Multiple

-The mentioned types aren't all types but these are the most common pumps types usually used.

-the common different between the centrifugal and Positive displacement pumps are:

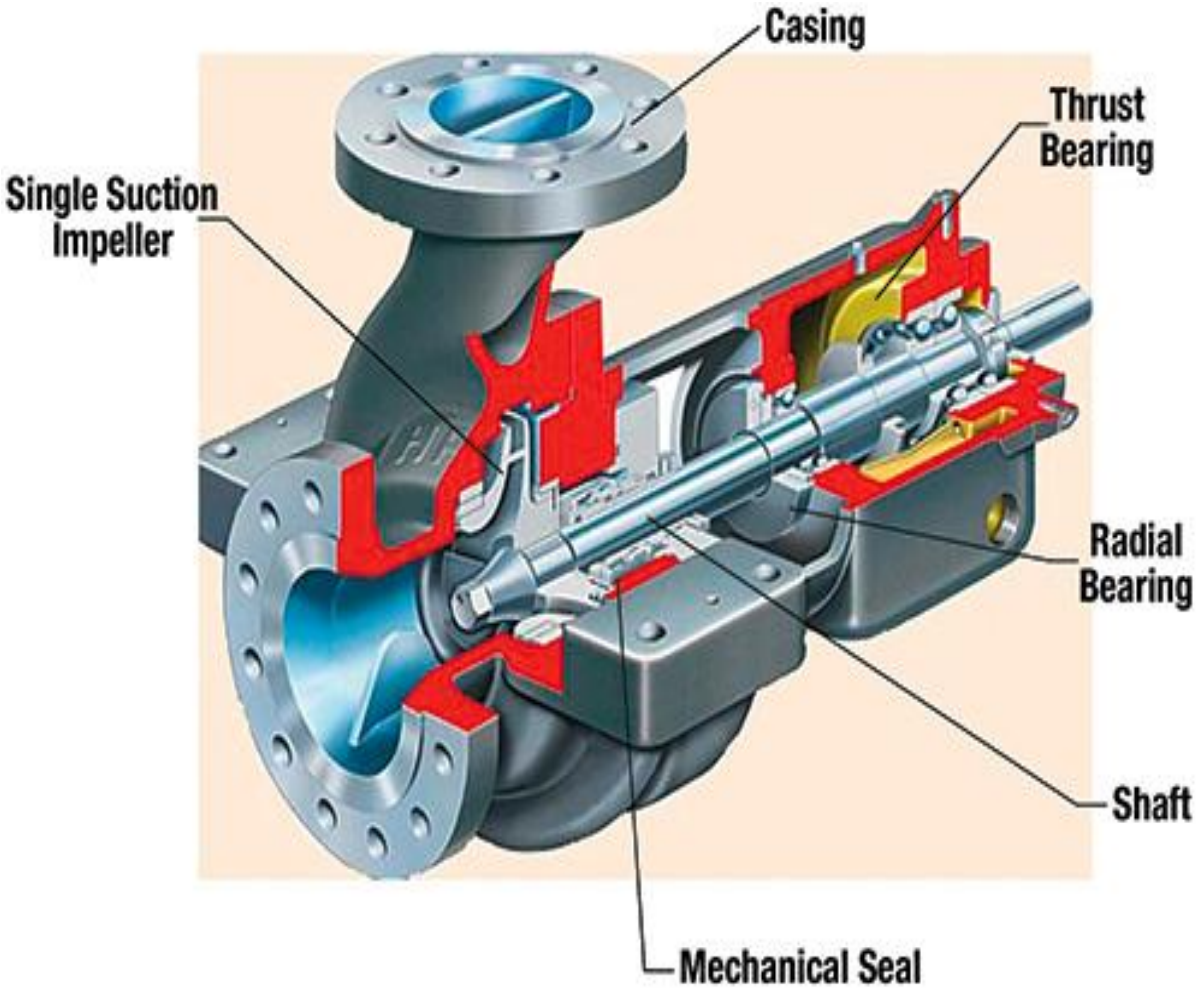
●In centrifugal pumps the kinetic energy is imparted to the fluid by rotating impeller generating centrifugal force which moving the liquid inside the volute rounding tangentially to the inside wall of the volute which pushes the liquid out of the volute of the pump as per the determined path out of the impeller casing in the opened line way.

●In Positive displacement pumps where the volume of the pump volute permitted volume for the flow is increasing by the shaft axial or rotating motion, where the liquid is moving to fill the emptied permitted volume then the motion of the piston or the shaft is pushing to decrease this permitted volume which pushes the liquid out of the volute according to gained positive displacement generated by the shaft(piston) motion.

►<u>We will discuss the first type (centrifugal pumps):</u>

●Its main Static Parts like (casing & impeller house volute-mechanical seal -packing)

●Its main rotating parts like (shaft-impeller-bearing has static outer part toward the pump body and other rotating part stacked to the shaft)



Centrifugal pump main parts

●-Centrifugal pump Precommissioning:

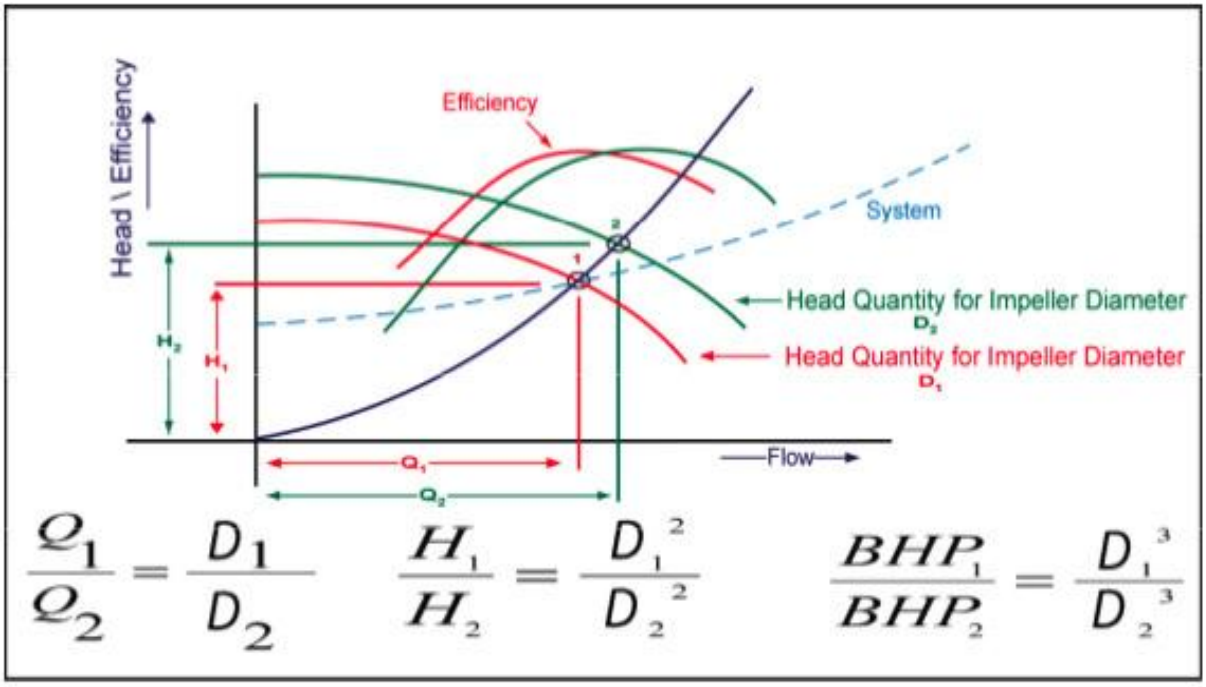
-Grouting of the pump metal basis to the concrete base with proper balancing to this metal basis by help of small and accurate bubble in water balance tool, the concrete base usually not perfect flatted, so using small and thin metal shims to be added around the fixing bolts of the basis to the concrete base, till you pick the most perfect balance.

-the motor of the pump to be mounted and properly balanced also by shims to the metal basis , then proper bolting.

-The Pump motor to be electrically connected after its outgoing shaft bearing to be greased and also the fan of the motor to be checked, from its back side free moving the after wards bearing to be greased properly , then connect its specific electric wire then check the electricity consumption at zero load running , if ok so proceed to other centrifugal pump parts assembly.
-The casing and impeller and the mechanical seal parts to be assembled by professional technician.

-If it is provided by variable speed gear box you have to check its erection progress with the mechanical team, check and report.

-the pump alignment as the shaft of the impeller and the shaft of the motor have to be aligned with the convenient instrument like laser alignment instrument , the difference between the motor shaft axis and the impeller shaft axis must be performed as per standard limits, this is properly reported during Precommissioning stage as any problem to be pointed out to the vendor of the pump., because misalignment is almost vibrating the pump and motor bodies and harms both side.
–The pump casing to be properly covered till suction and discharge lines fabrications reached.



Affinity laws for centrifugal pumps:

$$\frac{GPM_1}{GPM_2} = \frac{RPM_1}{RPM_2} \rightarrow GPM_2 = GPM_1\left(\frac{RPM_2}{RPM_1}\right)$$

$$\frac{TDH_1}{TDH_2} = \left(\frac{RPM_1}{RPM_2}\right)^2 \rightarrow TDH_2 = TDH_1\left(\frac{RPM_2}{RPM_1}\right)^2$$

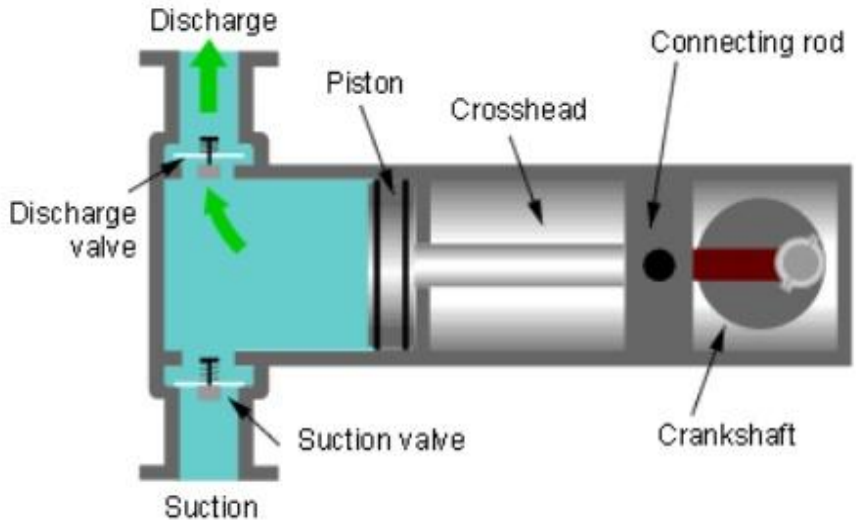
$$\frac{BHP_1}{BHP_2} = \left(\frac{RPM_1}{RPM_2}\right)^3 \rightarrow BHP_2 = BHP_1\left(\frac{RPM_2}{RPM_1}\right)^3$$

GPM>>Q , RPM>>N , TDH>>Head , BHP>>horse power

Positive Displacement Pump

Piston Pump

- Discharge pressure up to 50 atm…
- It's application is areas where high pressure is required… it is not necessary that every P.D pump be of 50 atm…



●-Positive displacement pump Precommissioning:

-basis and motor Precommissioning same as centrifugal pumps steps like-Grouting of the pump metal basis to the concrete base with proper balancing to this metal basis by help of small and accurate bubble in water balance tool, the concrete base usually not perfect flatted, so using small and thin metal shims to be added around the fixing bolts of the basis to the concrete base, till you pick the most perfect balance.

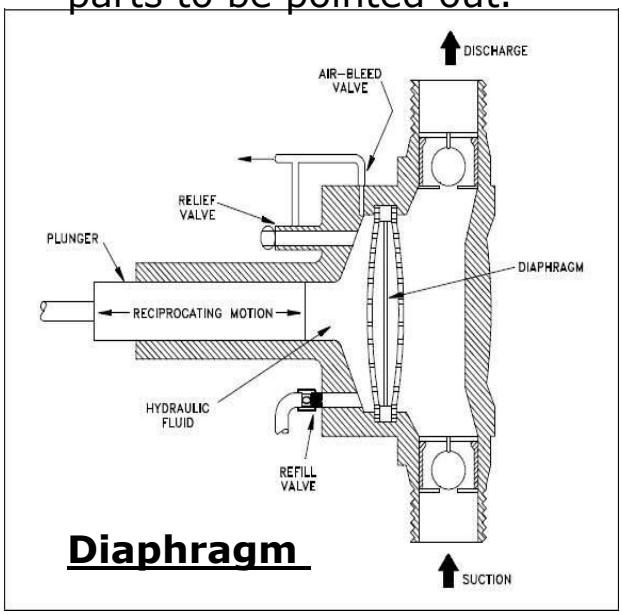
-in positive displacement pumps (as example Piston pump) the motor checked free and zero load.

-the piston and its casing to be assembled then the final grouting of the casing will be done, then motor to piston connected and standardized , then primary adjusting the stroke length and the piston motion frequency per min.

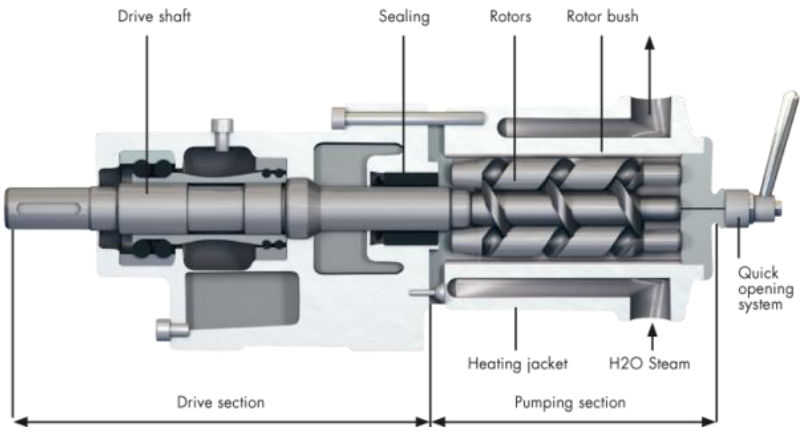
-If it is provided by variable speed gear box you have to check its erection progress with the mechanical team, check and report.

-the inlet and the outlet of the pump to be covered till piping fabrication reached not to collect dust.

-other pumps types like screw pumps interiors (rotors or rubber housing to the rotating screw to be carefully checked because if rubber is damaged or rotors are defected pump will not be operated properly any defects or parts not proper assembled parts to be pointed out.



Diaphragm



Screw pump

3-3-B Compressors Precommissioning:

1-Equipment Explanation:

►Compressors are other highly important and critical equipments, used in different Petrochemical plants, as the main function of any compressor is to compress and pressurize any gas or vapor ,for other services like:

-Gas/vapors volume reduction& discharging for storage.

-Gas/vapors pressurizing for feeding to service units.

-Vapors volume reduction for further condensation purposes.

●-The compressors are known as (the gas pumps) where its design from motor and its connections to the rotating part and also its motion delivering types are same to the main families which pumps are belonging.

●-Although the compressors and pumps are belonged to the same family, but the internal design of the compressors are designed for gas/vapor handling, with different small rotating and fixed internal and external parts rather than its similar family belonging pumps.

●-Compressors have more details related to their mechanical designs, which varies according to:

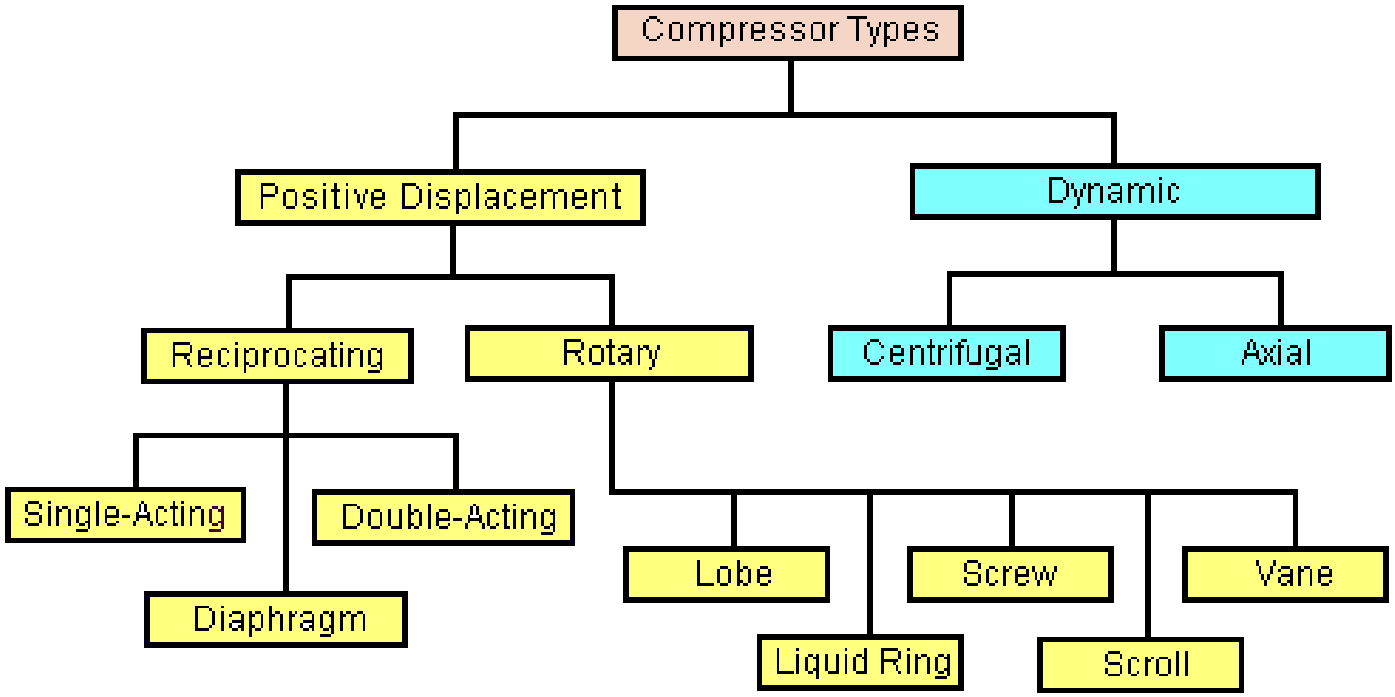
-type of the application material Gas or vapor.

-Chemical properties of the gas/vapor like its (corrosiveness, chemical composition its components and tendency to react or to deposit, or decompose)

-Physical Properties like suction operating conditions, like temperature, suction head , gas/vapor density & compressibility, entrained liquid in the flow probability)

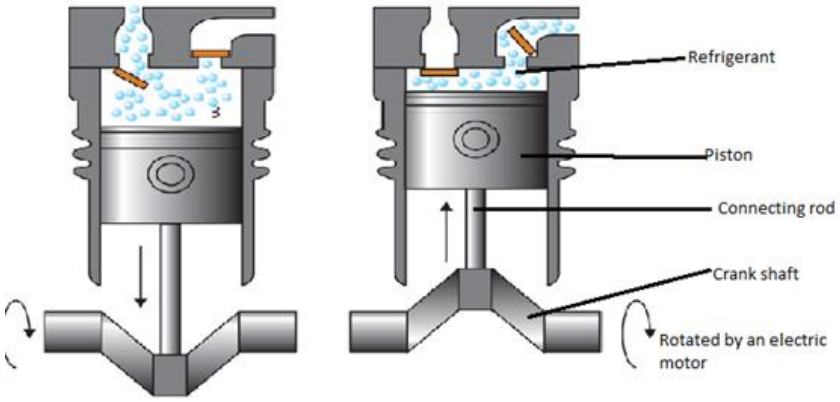
And as per all these variables the selection of the optimum compressors will vary.

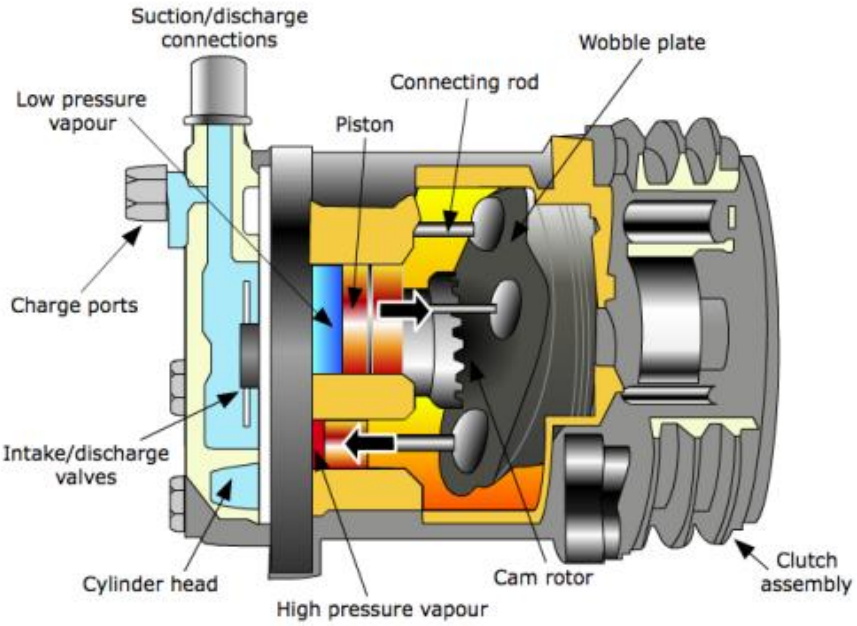
●The common compressors families and types:



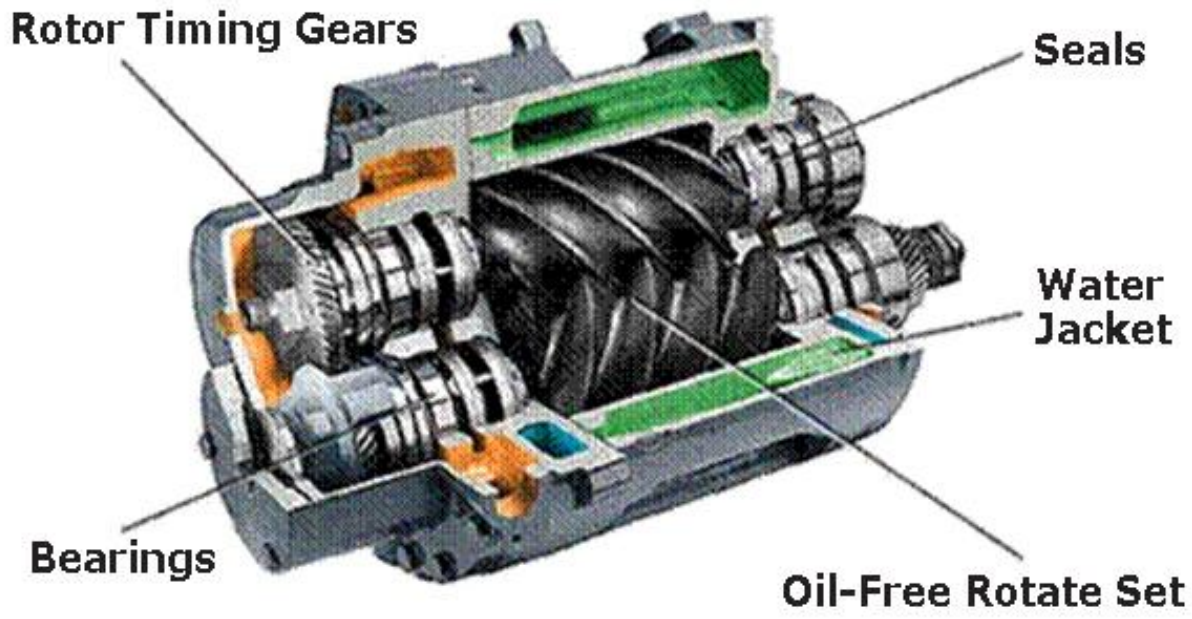
1-Positive displacement

A-Piston compressor double acting





B-Screw compressor

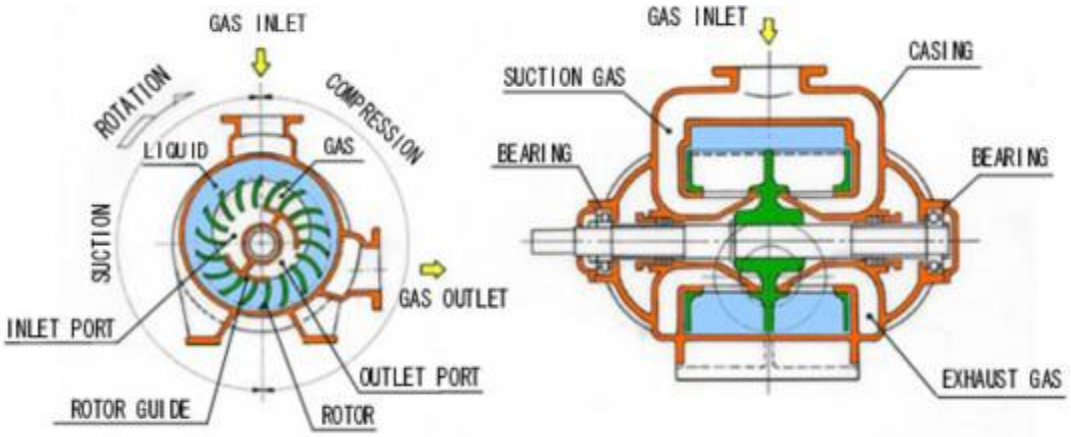


●- Equipment explanation:

As shown in the figures that positive displacement compressors mechanical principal is to enable free volume for gas sucking, then decreasing this volume by moving axially like piston motion without any centrifuge action, the gas is compressed pressurized and discharged to other tight volumetric stage after closing the back pressure way to the lower pressure suction and then directed to the discharge opened port.

Screw compressors has also many different details types according to the application

C-Special designed liquid ring compressor:



-Equipment Explanation:

As shown its mechanical principal the rotor impeller is eccentric and the gap between the impeller rotors and the casing internals are too much tight , Why?

This design depends on rotating the liquid around the impeller with hollow elliptical conned path along the impeller rotating part, to force the gas to move towards the discharge through gradually decreasing opening ports in the fixed

plates between the stages, this ports are designed in the way to allow the compressed gas to flow but with smaller volume till it reaches to the pump out let

-The main using of the this pump is used for vacuum generating for the entrained hot vapors coming out from the polymerization reactor in petrochemicals industries, liquid ring is rotating but the vapors flow is positive displacement moved.

●Precommissioning of positive displacement compressor:

-first step is participating the mechanical &electrical team to check the outer and inner parts of the compressor & it is same to designed or not, defected or not.

-if there is more than one compressor for same service check it will be connected in series or in parallel for proper grouting with the nozzle orientation drawing.

-If it is provided by variable speed gear box you have to check its erection progress with the mechanical team, check and report.

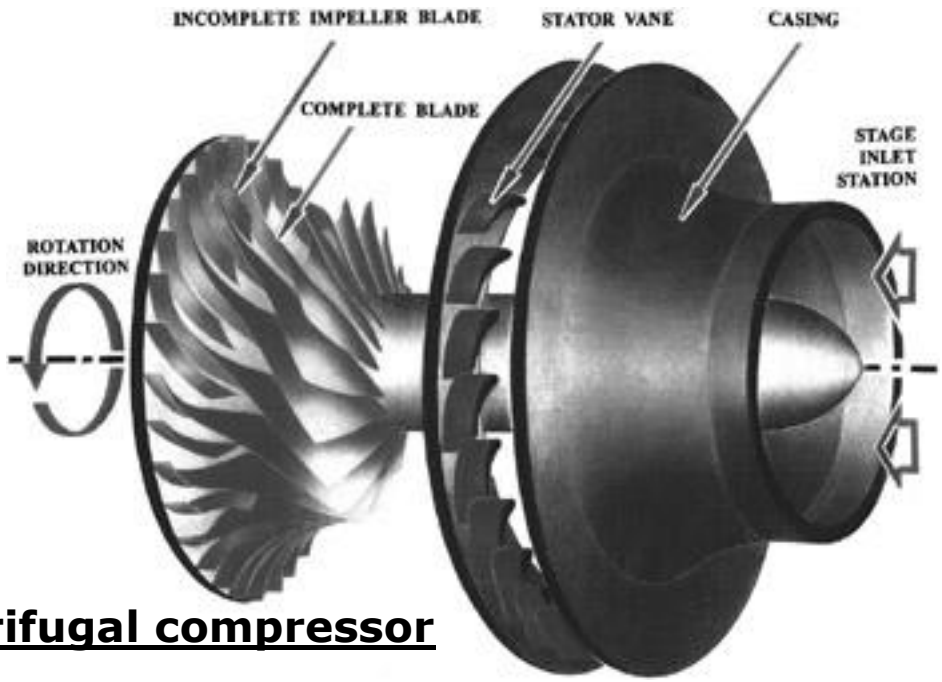
-Motor Direction to be checked typical to the design.

-check the assembly progress, and the oil pots or nitrogen vessels if there for sealing system check properly mounted and bolted.

-keep the suction & discharge flanges closed by built-in valve or any other way for proper protection from dirts.

2-Dinamic compressors:

A-Centrifugal compressors:



Centrifugal compressor

●centrifugal compressor Explanation:

as shown in this figures that the main parts of the compressor is the rotating impeller and the fixed plates with opening ports for flow path determining.

-the mechanical principal of the centrifugal compressor is to apply the centrifuge action to the gas which gains sufficient kinetic energy to move through definite port to the next compression stage which has smaller volume and hence this leads to final lower gas volume with higher discharge pressure.

●Centrifugal compressor Precommissioning:

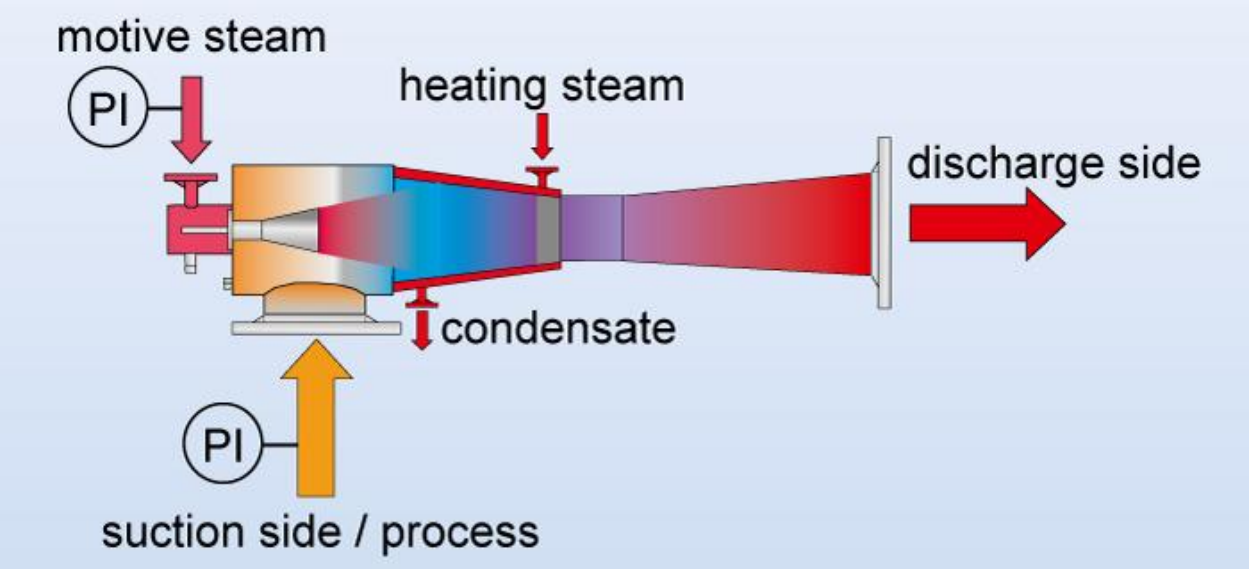
-first step is participating the mechanical &electrical team to check the outer and inner parts of the compressor & it is same to designed or not, defected or not.
-take care of the motor rotating direction this to be checked and revised with the electrical team.

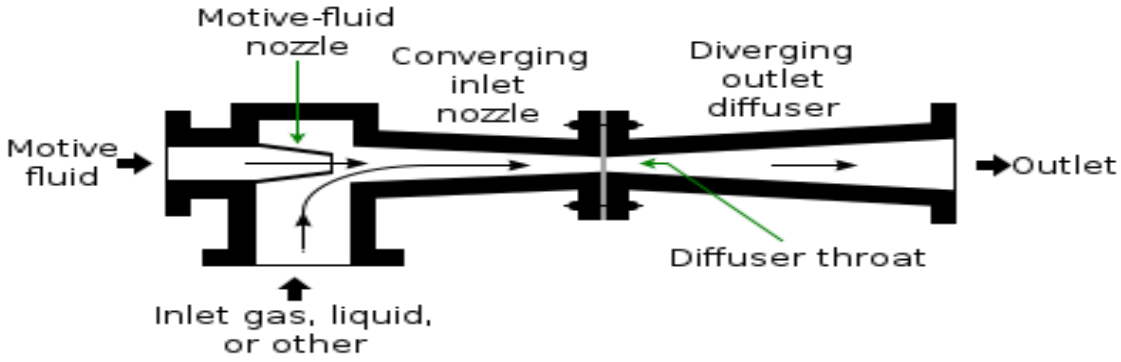
-if there is more than one compressor for same service check it will be connected in series or in parallel for proper grouting with the nozzle orientation drawing.

-check the assembly progress, and the oil pots or nitrogen vessels if there for sealing system check properly mounted and bolted.

-keep the suction & discharge flanges closed by built-in valve or any other way for proper protection from dirt

B- Vacuum Jet Ejectors:





•Jet ejector explanation:

-In spite this is a static equipment and hasn't any rotating part, it has a static mechanical gas/vapor pumping using the principal of venturi effect.

-used widely in the petrochemicals industry for reactors vapors recovery.

-Simply this effect depends on using a motive jet vapor or steam flowing to the inlet nozzle with high pressure energy which is converted to supersonic velocity at the nozzle neck then diffused to t the mixing suction chamber and meets the low pressure flow of the entrained vapors which is needed to be jet ejected.

-then the mixture is moved from the chamber to another converging nozzle with reduced area where the mixture velocity (sonic velocity) is converted into Pressure at the throat area.

-and then the mixture is passing through the diffuser with increased diverging area which discharged the mixture with lower velocity and higher pressure.

•**Jet ejector Precommissioning**:

-It's nozzles design to be checked, same dimensions in drawings and no defections
-This equipment is assembled in the field , and its parts have to be collected very tightly and properly mounted.
-Bolting to be done with the suitable bolts , and the recommended gaskets to be used, the operation is carried under low pressure or under vacuum system so leakage will be from out to inside ,and all the process will be troubled, so avoid this by proper bolting and gasketing.

3-3-C Agitators (Stirrers):

1-Equipment Explanation:

●Rotating part in stationary equipment(Tank or scrubber or reactor), used for:

-Mixing materials into other mixture with different properties.
-agitating one mixture in a heated vessel for homogenous heating of the mixture at all points of the vessel.
-agitating reactants in the petrochemicals reactors for better heat distribution ,better reaction conversion rate, also to librates any vapor bubbles in the mixture.

●Agitators may be mounted from top or from bottom ,or horizontally positioned ,as per the application required.
-As shown in the figures the type of the agitator selection varies according to the type of application as mentioned before, the volume of the vessel and the time of running

●Agitators main parts are :

(motor, shaft first bearing fitted to vessel, agitator shaft, blades, and fixing bearing if found.)

2-Agitator Precommissioning:

-First of all this part is erected after the erections and fabrication activities finished for the vessel where the agitator will be erected.

-The assembly of the agitator must be carefully proceeded and by professionals, specially the bearings and the sealing to be checked with mechanical team also.

-Agitator is erected to the vessel and aligned if possible, then to be fixed and bolted to the vessel seat then motor shaft connecting, after greasing and motor fan checking.

-If it is provided by variable speed gear box you have to check its erection progress with the mechanical team, check and report.

-some agitators are designed to run dry and other aren't, so in the commissioning stage we will try its direction and its control The agitator to be disconnected till further commissioning starts.

3-3-D Rotary Valves:

1-(Equipment explanation):

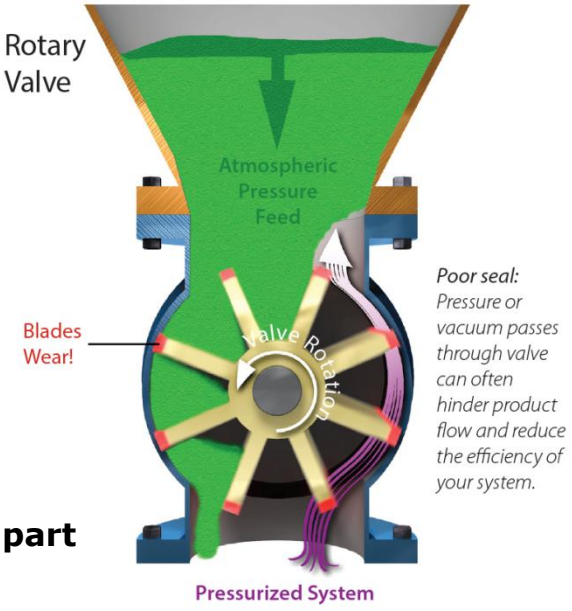
• Valves that are used for solid material like powder or polymer bullets handling from a vessel to another or to conveying line, like transferring the polymer chips or bullets from the last stage of polymerization to the conveying system to the storage tanks.

•This type of valves criticism is there position in the process, as they are almost transferring the raw material or finished product and its failing means that all the process before and after it will be troubled and many parameters will be affected.

•usually this rotary valve has variable speed gear box which controlling the flow from the stage to the next one, this also another critical part , as the adjusting of the rotary valve speed will affect the quantity which will pass , and if this material is transferred to conveying system this system will be troubled also or may be chocked.

•Rotary valve parts are shown like following:

Valve out case and other rotating internal part



●The rotary valve is derived by a sprocket chain connected to the rotary valve shaft from one side and connected to the gear box shaft from other side.

●Rotary valve inlet is designed by material guide to the rotating direction to avoid such material stack problem.

2-Rotary valve Pre-commissioning:

●The motor frequency to be checked zero load running, then this to be checked connected to the gear box at variable speeds , then the rotating system to be connected to the valve shaft.

●Bearings and packing to be checked healthy or not.

●The clearance between the rotating pockets and the internal side of the valve casing, to be adjusted as per technology recommendation, not to face stack problem.

●Rotary valves are directly connected by motor or connected by sprocket chain the length of the connecting chain to be also adjusted as per loads, and valve position, not to trip the rotating valve.

●Some types of rotating valves are provided with breathing and cleaning system, some Nitrogen tubes are connected to the body of the valve to provide Nitrogen cleaning out of the thin layer of the powder formed on the internal side of the casing, this system to be erected after the fabrication activities around the valve finished to avoid defecting.

3-4-Piping fabrications & fittings

-One highly blinking stage in the factory establishing is the piping fabrications & fitting , as all drawings are used to follow up this stage progress with daily, weekly and monthly reports and every small detail must have it's own fabrication history, &as following this is some types of drawings used to follow this stage :

- P&ID (piping and instrumentation Diagram)
- piping layout drawings.
- Vessels Nozzle orientation drawings.
- piping isometric drawings

And we will show some of these drawings later , other important documents must be used for proper and organized following reports like:

➡Check list hard copies

➡punch list hard copies

➡progress report soft copies

➡field point out history report soft copy

➡piping loop list

➡piping alignment , gasketing and bolting point out reports soft copies.

➡fabrications and erection permits hard copy.

Here are some Drawing and Documentation samples which are used in the Pre-commissioning stage：

2.Equipment Legend:

1		Centrifugal Pump
2		Centrifugal Blower/Fan
3		Gear Pump
4		Diphragm Pump
5		Air Compressor
6		Screw Pump
7	M	Electric Motor
8		Inverter
9		Transducer
10		Gear Reducer (fixed/adjustable)
11		Fixed Tubesheet Heat Exchanger
12		Liquid-vapor Separator
13		Filter
14		Nozzle
15		Sight Glass,Light Glass
16		Ejector
17		Evaporator
18		Plate-type Heat Exchanger
19		Agitator
20		Static Mixer
21		Vertical Reactor
22		Horizontal Tank
23		Vertical Tank
24		Cooling Tower
25		Rotary Feeder
26		Vibrating Screen
27		Process column

3.Equipment TAG No.

L-A XX YY Z-BYY
- L: Auxiliary Equipment Serial NO. (01-99)
- A: Auxiliary Equipment Identifier (A-Z)
- XX: Index (A-Z)
- YY: Equipment Serial No. (01-99)
- Z: Plant Section (01-99)
- B: Equipment Identifier (A-Z)
- YY: Line No. (1-9) (Only in case of more than 1 line)

Examples :

1-P1401A-M01 : Electric Motor M01 of Pump P1401A in line 1

R0801-A01 : Agitator A01 of Reactor R0801 (Only single line)

IV. Valve

1.Valve and Accessory Legend:

No.	Legend	Name	Code	Symbol
1		Sampling Valve	SP	300
2		Globe Valve	JV	301
3		Gate Valve	ZV	302
4		Plug Valve	XV	303
5		Ball Valve	QV	304
6		Butterfly Valve	DV	305
7		Check Valve	AV	307
8		3- Way Valve	LW	320
9		Four-way Valve	FW	321
10		Angle Valve	A	322
11		Slide Gate Valve	GV	323
12		Special Triple Valve	TW	324
13		Safety Valve (overpressure / vacuum)	SV	330
14		Rupture Disk	SP	331
15		Reducing Valve	R	340
17		Float Valve	FV	341
18		Spectacle Blind Valve	B	350
19		Y Type Strainer	F	351
20		Restriction Orifice	HO	352
21		Flame Arrestor	FR	360
22		Jacket Valve	BV	361
23		Diverter Valve	HK	362

2.Piping,valve and accessory Representation:

2.Standard Valve Representation: 2.Piping,special valve and accessory Representation:

XXXX — Nominal Diameter; Valve Type

XXX-XXX — Parts Solid Matter; Parts Symbol

3.Erection material abbreviation please see pipeline standards document

V. Instrumentation Legends.

1.Signal Line:

No.	Legend	Name
1		Process Instrument Connection
2		Instrument Signal
3		Electrical Binary Signals
4		Capillary
5		Mechanical Connection
6		Pneumatic Connection
7		Pneumatic Binary Connection
8		Hydraulic Pressure Connection
9		Guided Wave Or Sonic
10		Non-guided Wave Or Sonic
11		Internal System Link (Software OR Data Link)
12		Chemical Seal
13		Undefined

2.Control Valve:

No.	Legend	Name
1		General Control Valve
2		General 3-Way Control Valve
3		General Four-way Control Valve
4		Bottom Discharge Valve
5		Angled Control Valve
6		Ball Valve
7		3-Way Ball Valve
8		Four-way Ball Valve
9		Globe Valve
10		Gate Valve
11		Butterfly Valve

3.Control Valve With Self Actuated:

No.	Legend	Name
1		Self-operated Reducing Valve
2		Self-operated Backpressure Valve
3		Pressure Reducing Adjust
4		Backpressure Adjust

4.Online Instrument:

No.	Legend	Name
1		General Online Installation Instrument
2		Variable Area Flow Instrument
3		Variable Area Flow Instrument With Upper Cut-off Valve
4		Variable Area Flow Instrument With Lower Cut-off Valve
5		Single Pitot Tube
6		Multi-Pitot Tube
7		Turbo/Thruster
8		Target Type Sensor
9		Vortex Sensor
10		Ultrasonic Flowmeter
11		Displacement Meter
12		Electromagnetic Flowmeter
13		Flow Nozzle
14		Differential Pressure Orifice Plate
15		Quick-replaceable Orifice Plate
16		Purge Type Rotameter
17		Mass Flow Meter
18		Current Indicator

5. Discrete Instrument Symbols:

No.	Legend	Name
1		Field Erection
2		Accessorial parts in Primary Unit
3		Non-accessorial parts in Primary Unit
4		Accessorial parts in Assistant Unit
5		Non-accessorial parts in Assistant Unit

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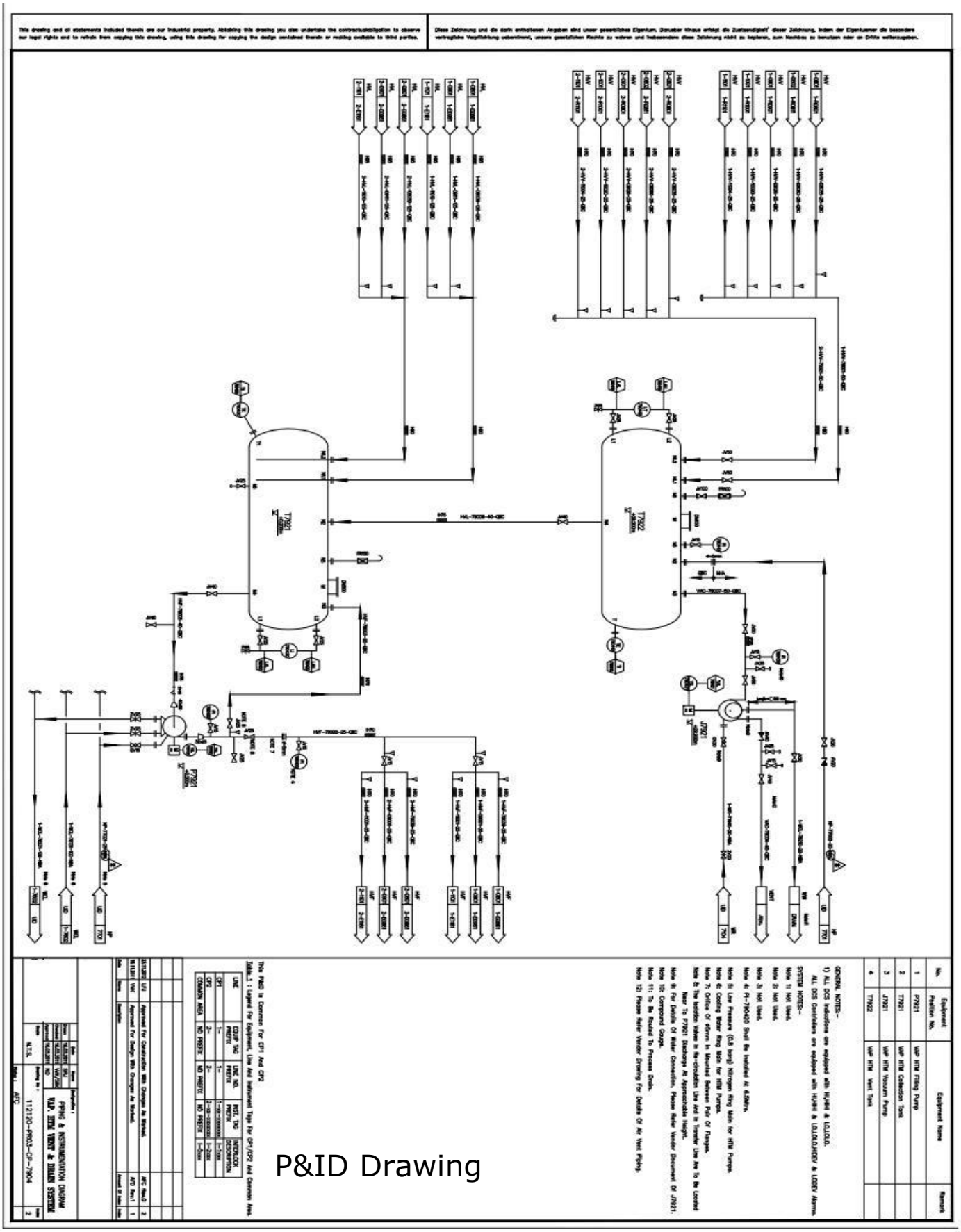
PIPING & INSTRUMENTATION DIAGRAM

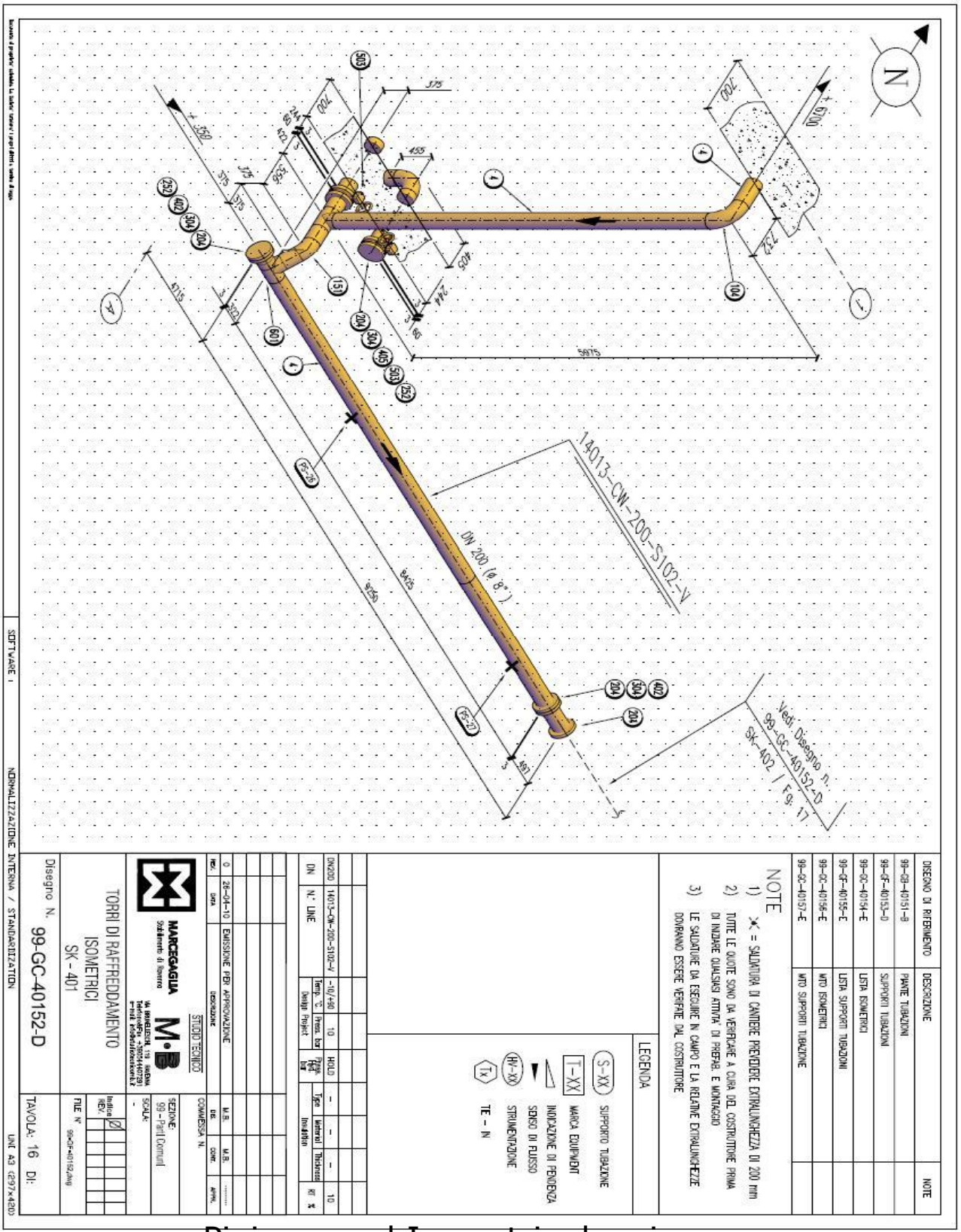
GENERAL LEGENDS-2

N.T.S. — 112120-PR03-CP-0002 — 0

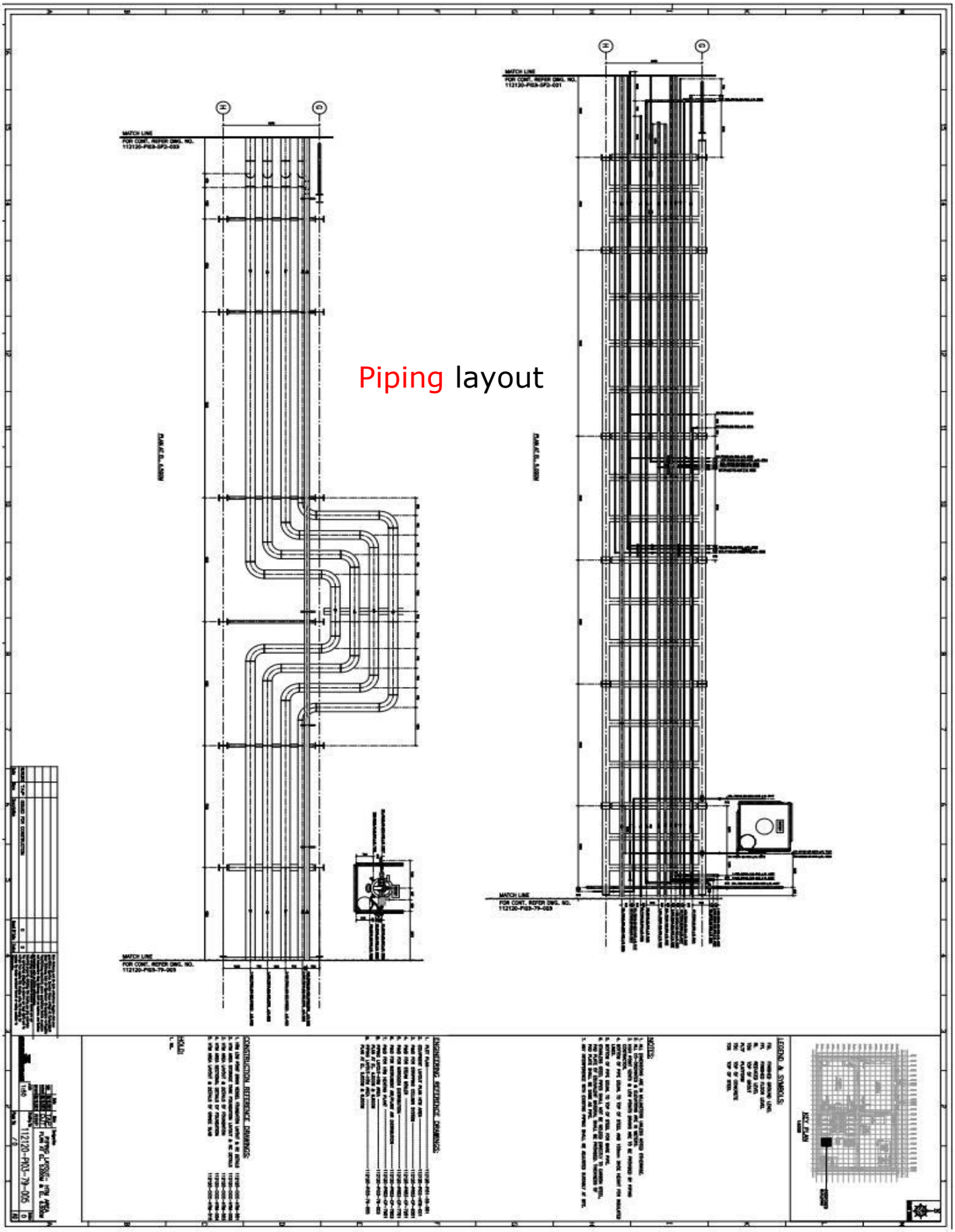
AFC

P&ID legend keys


P&ID Drawing



Piping spool Isometric drawing



Piping layout

The main role for process/operation side during this stage is to follow up and report the progress of the piping fabrications , supports and taping proper orientation , bolting and gasketing and piping alignments reports.

Where the insulation is started after the piping fabrications finished and loop tested properly ,, the following of insulation is on important point operation & mechanical teams has to follow not to miss any instruments taping or covering any flange needed by wrong way , this point can save more time for project start up and so more money and efforts also.

The insulation has two common material types Hot insulation for hot service lines , and cold insulation for cold service lines and proper insulation can save more energy ,and helps for process energy conservation which will affect the product price directly according to Energy used per metric ton of product .

-Every pipe spool has its own definition number contains the material which will pass through the pipe , and the pipe configuration by the area tag number and then pipe diameter measurements ,then the material of the pipe like steel grade , then the abbreviations of the operating conditions, this is defined for any plant by the P&ID legend which contains all figures and abbreviations of the technology special drawings for the plant.

-The fabrications jobs are carried out by the suitable welding or fitting according to the type of the metal, also according to the physical and chemical service material

and according to the operating conditions all these jobs are followed by the drawings of the specified area.

-at these stage where the mechanical construction is generally Proceeding with the collecting data reports from the QC team , Mechanical team , and operation/process team.

-what to be checked from process side:

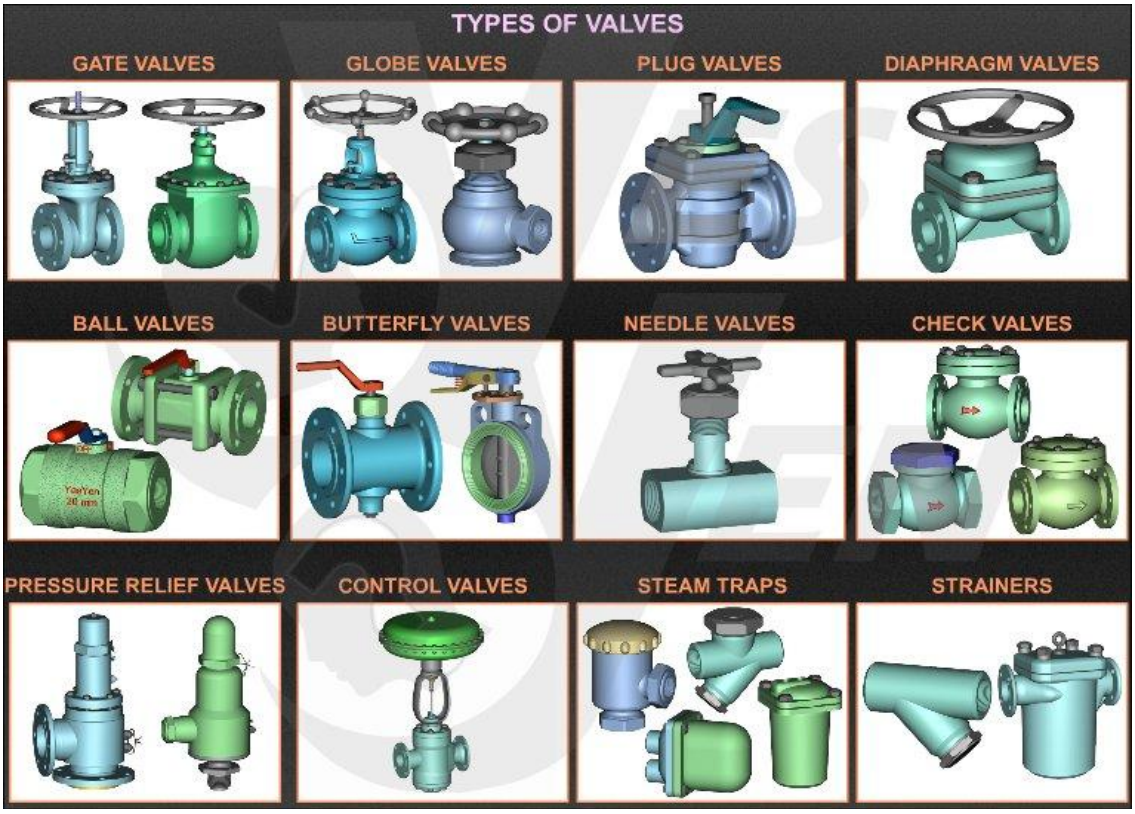
●**Piping metal** type is typical by cross sight (stainless steel or carbon steel or galvanized)

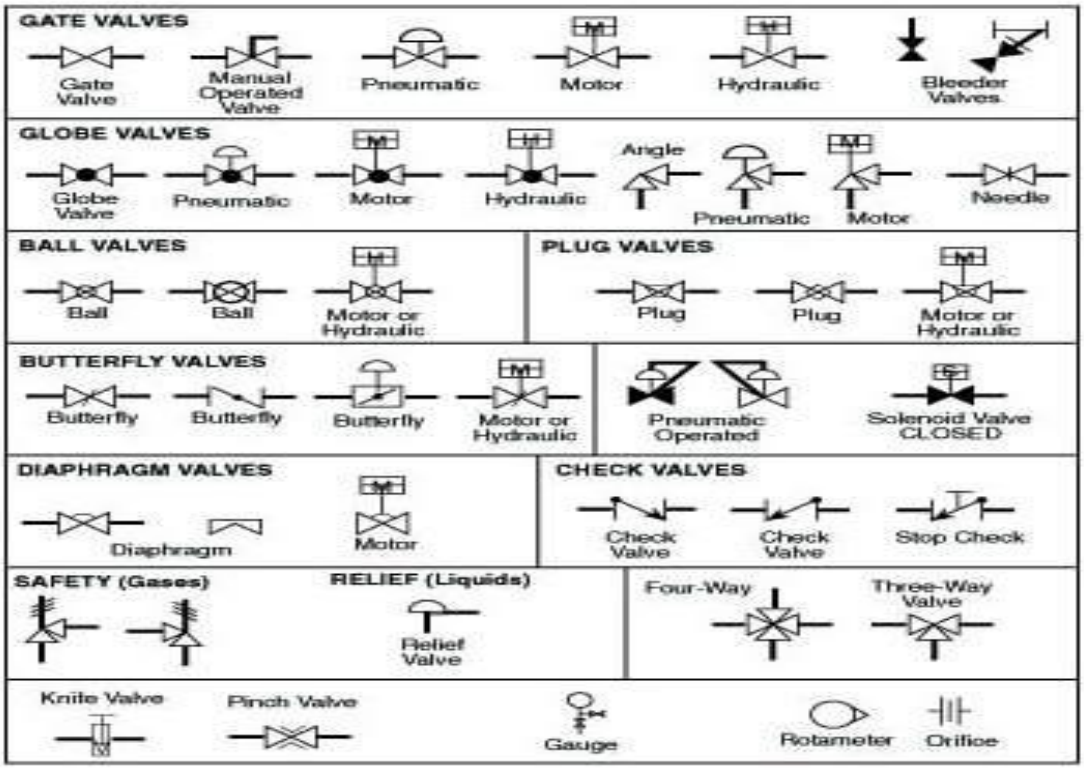
●**Valves** and Taping are in the right position and also it must be safely reachable from operation and maintenance team after starting.

●The type of valve is typical for designed (Butterfly valve , Gate valve , Globe valve and its direction , Non-return valve and its direction , needle valve , Ball valve, angle valve , damper valve , safety relief valve …..etc,)

●The type of valve metal it is similar to the Piping material or not as erection of different types of metals with operation (like stainless steel valve on carbon steel Pipe or vice versa will promote corrosion and valve damage).

●The type of valve metal / material must be identical to the service material chemical properties , and its selectivity according to the operating conditions.


TYPES OF VALVES
GATE VALVES
GLOBE VALVES
PLUG VALVES
DIAPHRAGM VALVES
BALL VALVES
BUTTERFLY VALVES
NEEDLE VALVES
CHECK VALVES
PRESSURE RELIEF VALVES
CONTROL VALVES
STEAM TRAPS
STRAINERS


GATE VALVES
Gate Valve
Manual Operated Valve
Pneumatic
Motor
Hydraulic
Bleeder Valves
GLOBE VALVES
Globe Valve
Pneumatic
Motor
Hydraulic
Angle
Pneumatic
Motor
Needle
BALL VALVES
Ball
Ball
Motor or Hydraulic
PLUG VALVES
Plug
Plug
Motor or Hydraulic
BUTTERFLY VALVES
Butterfly
Butterfly
Butterfly
Motor or Hydraulic
Pneumatic Operated
Solenoid Valve CLOSED
DIAPHRAGM VALVES
Diaphragm
Motor
CHECK VALVES
Check Valve
Check Valve
Stop Check
SAFETY (Gases)
RELIEF (Liquids)
Relief Valve
Four-Way
Three-Way Valve
Knife Valve
Pinch Valve
Gauge
Rotameter
Orifice

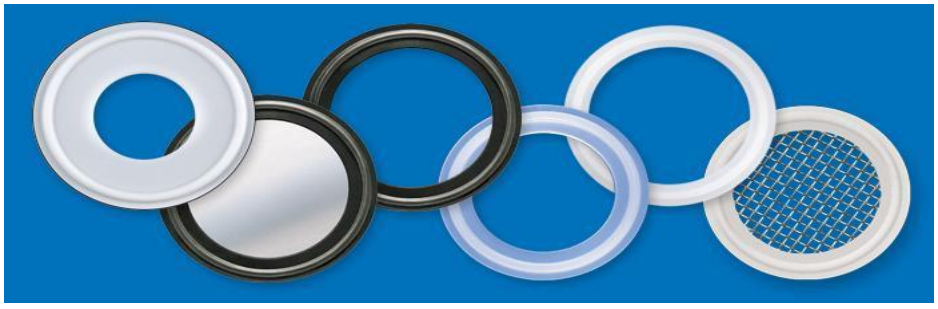
●**The bolting** for all flanges must be checked that all bolts with their combatable nuts are erected, with the same specification of the flanges and the service materials specification.

●The bolting must be applied with piping flanges axis safe limit alignment , not to make over torque during operation , and this may lead to heavy leakage with large harmful results where all these activities are followed by daily check lists and progress reports from process/operation side.

●The primary bolting and commissioning bolting and final bolting must be applied during attendance of one of process team,, handing over the improper bolting will lead to more wastage for time , efforts and materials during start up.

●**The gasketing** is a very important mission to be checked by process team , where the type of the gasket is same to which is selected by designers like (English paper gasket, Teflon gasket , metal spring gasket ,…..etc.) where the gasket type must be convenient to the type of service conditions which will be applied on it like (hot or cold , corrosive or not ….).

●Any gasket erected ID & OD has to be checked it is the same needed for specified flange , and we have to assure it is undamaged , to avoid further leakage and process troublemaking.



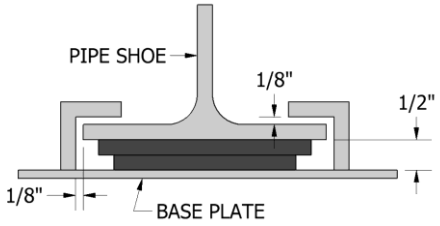
•**Piping Supports** is another part of the fabrication following mission,, whatever the design support for specific piping spool , the reporting of checklist is the supports is fabricated or not but there is another details to be taken in mind of who is checking the type of support is a very important detail not to be passed , it is hidden and small but if it is not proper selected and proper fabricated it may cause a big loss for either the equipment or for the material flowing leakage ,

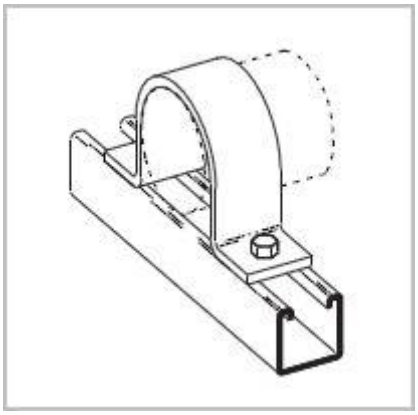
according to our experiences the more vibrating parts of the piping systems specially near to the pumping systems must have a motion permitting support like (spring supports if the vibration is generated in vertical or random directions motions , and according to the force acted on the pipe because of this vibration the volume and the elongation of the spring of the support is adjusted.

& if the motion of the Piping is horizontal some other types of supports are applied like guided support it is action like track which is permitting to the pipe to move in definite direction and prevent it from moving in other direction ,,

these guided supports if not selected properly or fabricated properly this may lead to (either rotating equipment damage because of improper vibration releasing because of support counter restriction to the piping which reflected to the connected equipment to this pipe or this wrong movement restriction may damage the piping welding or fitting).

So the checking of supports is critical job to be carefully checked and here some types of supports (flexible support , spring limitation support , guided support , non guided support….).





●Piping internal elements like orifices and filtering web , solids arrestor to be properly checked.

●One more thing to be strictly informed to all contracts not to leave any solid pieces or strange bodies inside the pipes , as these things will cause more troubles during commissioning and startup like line chocking.

Chapter 2

Petrochemicals Plants and oil Refineries projects 2nd phase

Commissioning & dummy batch Phase.

-Projects 2nd Phase

-Commissioning& dummy batch phase:

1- Utilities commissioning and receiving.

2- Piping flushing& loop testing.

3- Stationary equipments commissioning.

4-Instrumentation erecting &Distributed control system loops& logic checking.

5- Tanks &vessels level calibration & cleaning.

6-Rotating equipment commissioning.

7-Fluid circulation and raw material receiving.

8- Heating and hot bolting.

9- Startup sequence trial on water and nitrogen& raw material feeding for startup.

10- Sampling and parameters tuning for commercial standardization

11- Post commissioning& Process modifications and SOP setting for capacity enhancement.

12-Performance check for lower, normal &maximum capacity.

1-Utilities commissioning and receiving:

A-Activity definition:

►Utilities are the lungs of any petrochemicals plant, as from its name , it is utilized at every point of the plant.

-Utilities are the start step of the actual plant operation stroke toward the commercial production.

-Common types of utilities:

I. Process /conveying air with 5 to 10 Pars
II. Instrument air with lower than 5 pars
III. Nitrogen High and low pressures
IV. Service water
V. Raw/Drinking water
VI. DM water with less 10 Ms
VII. High pressure super heated steam
VIII. Low pressure steam
IX. Chilled water 2 to 10 degree c
X. Cooling water 14 to 18 degree c
XI. Heating Dowtherm oil.

-All these utilities loops ISBL (inside battery limit) ,these loops piping testing and commissioning is the responsibility of plant operation team not utility team, that means that first loop to be completed is the process air loop.

B-used tools for Air loop testing:

-Gaskets , bolts , soaps in water mix, fitting tool kits.

C-Testing& commissioning Procedure:

First of all the loop to be closed that mean it is blinded by blind or by manual valves, all instruments to be removed only local pressure gauge to be used.

Then start pressurizing the process air loop directly from utility , and when pressure reches to 1.5 or double times of the operating pressure close the loop taping, and cross check if there is any fast pressure drop , so check the sound of the air leakage, if not obvious so use soap/water mix bottles and check all flanges , fittings and welded point, bubbles will be directly generated from the leaking points.

Then mark the leakages and ask to the contractor of the area to attend the leakages.

Then again repeat the same procedure till you find the pressures held for some time, so keep it held one day and night then next day check the pressure drop is within the restriction limit or not.

-if ok so report, proceed for next planned loop and remove the blind to use the process air service points for further commissioning of other loops and equipments.

►same sequence used for all other utilities loop.

2- Piping flushing& loop testing:

A-Activity definition:

- Real critical stage of the commissioning stage as the piping is considered the arteries and veins of any factory, feeding and bleeding ways for all material transferred from equipment to another, piping loops are segregated and divided as per same factors like:

- Same service material flowing.
- Same operating conditions P &T°.
- Same area Sub-loops.
- Same metal type.

-Piping loops to be divided between the commissioning team members for proper following and reporting.

-After fabrications, erections and cold bolting finished so we arrange the required tools and distribute the team for the checking of the loops with the using of loop lists.

B-used tools for piping loops testing:

-(Tool kits- Pressure gauges- PPE- Pressurizing hoses –Gaskets- Hard cartoon sheets-liquid soap –markers –F keys)

C-Testing& commissioning Procedure:

-firstly we have to check the piping loop , take around check the start point and end point of the loop, check all branches.

-Then check all connections to the vessels and equipments and ask to fitters for blinding and bolting.

-Check the nearest water and air service points.

-Check the recommended test medium and test pressure for every loop by the technology supplier documents.

-Close the start and the end manual valves and remove all instruments if erected ,or proper blind isolate and for automatic control valves isolate and use the bypass line.

-Erect the pressure gauge on proper mounted taping and erect the pressurizing hose kit to another far taping.

-First step is to clean and flush the piping loop using the meaning of air or water as it is recommended usually to use water flushing for stainless steel cleaning, and using air blasting flush to carbon steel piping loops.

-The flushing or the cleaning proper procedure is going on moderate pressure from top purging point to the lower drain point.

-Flushing and cleaning is performed time after time and repeated till the drain or the blasted air is clean and free of dirt and dust.

-Then going to the next step of pressurizing the loop , the safety first must be applied by both the commissioning tea leader and the safety officer , as pressurizing the loop will start gradually from low pressure and taking around the loop checking the voice of the air leakage if the air is the testing medium , or detecting any water leakage if the water is the used medium ,if no leakage detected , go on for next step.

-If loop was pressurized at low pressure and for short time and no leakage detected so , proceed for the next step and increase the pressure slowly till the normal operating pressure then take around the loop and check all welding joints and bolted flanges for detecting any leaking using soap/water mix for air tested loops , or directly check the water leakage for water tested loops.

-If check ok ,and no leakage detected so proceed for the next stage and pressurize more to the maximum operating pressure , and hold the pressure for 4 to 8 hours then check the leakage, if there is any detected leakage report it to the area contractor to attend it after online if bolt need only to be tightened , or after releasing the pressure if any gasket damaged and need to be changed , or by detecting any welding leakage so don't attend the welding under pressurized loop you firstly release the pressure totally then attend it .

-If welding leakage attended so wait till the welding cooled down avoid thermal chocking of the metal ,and again repeat the pressurizing process, and proceed for the next higher pressure till 1.5 to 2 times of the operating pressure you have to check the maximum permitted pressure test for the commissioned loop.

- Hold the pressure for 24 hour as recommended by the technology supplier.

-After holding check the pressure drop if accepted so proceed to final step , release the pressure and mark the piping loop as cold test performed and submit it for next hot testing or direct commissioning flow circulation if it will run at normal pressure.

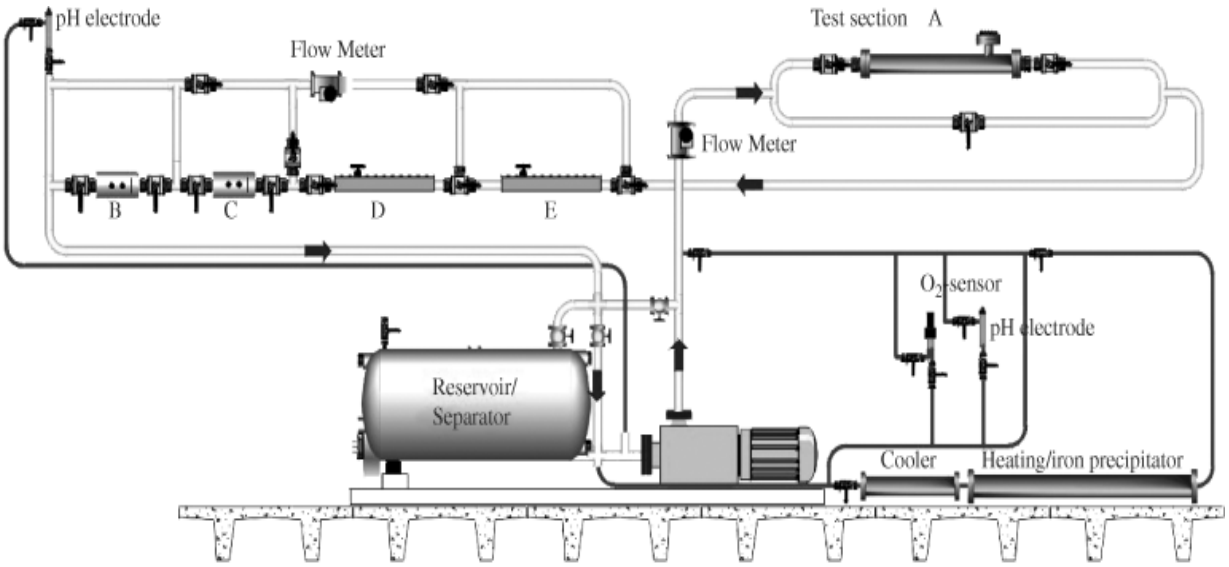


Figure 2. Diagram of flow loop apparatus (Courtesy of IFE, Norway).

-Piping connections with the equipments, vessels and tanks are to be kept isolated till these connected equipments also cleaned flushed and tested.

3- Stationary equipments commissioning:

A-Activity definition:

-This stage has many steps for proper checking and preparing for circulation mode and these steps are as following:

- Using the equipment lists for the plant then specify every area for one team, and give them recommended pressurizing medium and recommended pressurizing limit , and cold test only or hot test is recommended for post heating the system
- Cleaning from inside the equipment by housekeeping if confined space safety permitted for such equipment.
- Or cleaning from inside by using water flushing from top to bottom drain.
- If water not permitted air can be used for dust releasing by mild pressurizing by the air to definite point then start opening the drain manual valve for releasing dust and solid particles.

B-used tools for Equipment testing:

-(Tool kits- Pressure gauges- PPE- Pressurizing hoses –Gaskets- Hard cartoon sheets-liquid soap –markers –F keys)

C-Testing& commissioning Procedure:

- At this stage all instruments connected to the equipment body aren't permitted to be connected to this the equipment body at this stage.

- After equipment is cleaned from inside so check internals for last time ,then proceed for boxing up the manholes by the recommended cold bolting and proper healthy gasketing , then start pressure testing.

- Some of the tested equipments are running at atmospheric pressure and others are pressurized so this to be taken in mind.
- After boxing up and erecting one or more pressure gauges around the equipment with isolation manual valves start use the air or nitrogen or water supply whatever recommended for every equipment, to pressurize the equipment start with high attention at low flow.
- If any hammering heard, so this to be analyzed properly and checked what is the problem is this supporting problem or some internal parts failed.

- If ok so proceed for higher pressure and hold at recommended pressure and hold for 4 hours check all pressure gauges if pressure is coming down so use soap/water mix for detecting the leaking points. And attend them under pressure is permitted if not possible so release all the pressure and then attend the leakages whatever it is from welding joint ,or from gasket damage.

- Some equipments have to be checked by special procedures like Shell and tube heat exchanger it has special way as following:
    1. We have to remove the cover of the tube sheet from the fixed side.
    2. Then properly tight all the bolts fixing the tube sheet with the shell body, in x or star ways as recommended not to damage the gasket from one side.
    3. Blind all flanges connected to the shell and leave only two flanges one for connecting pressure gauge and other for connecting water hose.
    4. Start feeding cold water to the shell side and pressurize slowly till recommended pressure then hold the pressure, and check the tubes openings if some water is coming from any tube , you have two choices , first is to blind the tube with the proper metal blind, or if you want to remove it this will be costly time and manpower specially if it is big bundle.
    5. If no leakage so box up the cover removed properly not to damage the metal gasket.
    6. Coils are treated as one tube isolate and pressurize .

●Other special equipment testing is the Plate and frame heat exchanger it's testing like following

1. Firstly the boxing up of the Plate and frame heat exchanger must be as recommended gaskets are to be proper mounted way ,not to reverse the rubber gasket

path as this will reverse the flows inside the H.Ex or material internal mixing.

2. For proper checking and testing , one healthy pressure gauge is erected at the out let of one material side say (hot flow side) and the water is supplied through one hose at bottom drain of the hot flow side , then all inlet and inlet manual valves to be closed.
3. Pressurize the hot flow side till the recommended test pressure slowly , then hold the pressure .
4. Check all plates &gaskets for no any water drops leaking, if there is any leakage , so carefully tight the holding rods of the PHE and assure that you don't exceed the minimum thickness of the collected plates and frames, because over tightening will damage the rubber gaskets.
5. Then after attending the external leakage we have to open the drain of the other cold flow side for checking there is no internal leaking, if detected water coming from cold flow side so you have to open and check all rubber gaskets again for any reversed or damaged gasket, then box up and recheck again ,if ok proceed.

4-Instrumentation erecting &Distributed control system loops& logic checking:

A-Activity definition:

- Here after pressurizing and testing for the piping loops and equipment is in progress this is the followed stage is to erect the instruments on the piping and on the equipments body for connecting to DCS or PLC
- DCS is Distributed control system and its explanation is a type of control system consists of dividing process controls, each is managed by its own controller with the whole system connected to form a single entity usually by means of communication buses &it is applied for manufacturing dynamic system in which the controller elements aren't central in location. Like brain control , but controller elements are distributed throughout all the plant with its subsystem component, Where all the entire system of controllers are is connected with net works for communicating and monitoring
- DCS is dealing with large number of Inputs and outputs (I/O) cards with less cost, where DCS system is a group of individual smart controllers having the connection with the field devices doing their specified operation duty inter connected.
- PLC is the Programmable Logic Controllers and it is explained by the applied control system for small systems in the field with less Input/Output cards

where these cards may be digital or analog, and the PLC processor has the software basis which receives the Inputs from the device and then gives Output commands back to the device in the field.

- In petrochemicals field both system are applied ,PLC is used for small individual systems like (Bagging machines, Fired heater burner control, Chippers or polymer cutters….)
- The automation team are proceeding to erect all types of instruments or control valves for finished tested loops and equipments like following some types of instruments widely used:

1. Pressure (field indicator, or controller – Pressure high or low limit switch)
2. Temperature(field indicator, or controller-Temperature high or low limit switch)
3. Level (field indicator ,or controller – Level H or L limit switch)
4. Flow meters indication with totalizer or flow meter controller.
5. Speed controller for rotating parts.
6. Viscometers
7. Density meter
8. Schenck controller (powder flow control and feeder)……

And more other special detectors for gas , flame …..etc

After erecting the instrument it is checked with logic setting up in the DCS(control room) for adjusting feedback and feed forward.

And commissioning for control valves and its tuning is performed in this stage for controlling its peak response speed and its maximum and minimum opening also control valves are to be set for direct or reverse opening with the controller, and its selectivity as per fail to open or fail to close according to the its function and the process requirements.

-All motor to be connected at this stage with the coordination between electrical and instrumentation team, for following the motor signal from and to the DCS is correct and proper direction rotating.

5- Tanks &vessels level calibration & cleaning:

A-Activity definition:

-Tanks and vessels of all the plant are listed in one list indicates its design shape and its volume and the height between the level low and high limits.

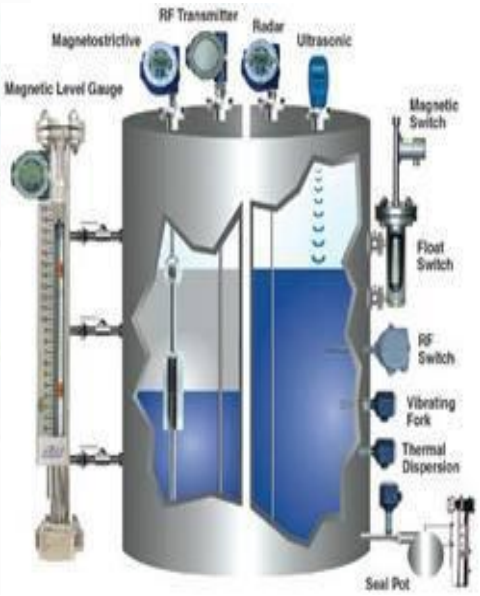
-As there is many shape of tanks every tank has its own shape :

1. cylindrical Horizontal shape with elliptical head or hemispherical head or torspherical head or flat head
2. cylindrical vertical with elliptical or hemispherical or torspherical or conical head
3. Spherical Tank

-Every shape of tank has its own level calibration procedure and the procedure will differ from shape to other and also will vary with the volume of the tank according to the level range length in Cm between the lower level indicator and the higher level of the tank.

-Dead level of the tank one other critical part depends upon the distance between the lower level indicator nozzle and the bottom of the tank, maybe it seems to be small distance but in fact this small vertical distance will make big dead volume when multiplied with the cross sectional area , it is very important to calculate this volume which also will vary with the shape of the tank as following:

Shape of the liquid will vary with level increasing or decresing,



B-used tools for tank calibration:

1. Water hose with nozzled flange.
2. Transparent capillary tube with nozzle.
3. Water Rotometer.
4. Water micromotion flowmeter.
5. Measuring tape.
6. 1mtr cubic standard drum.
7. Level to be calibrated must be connected to DCS and electrically connected.

C-Tank Calibration Procedure :

-Firstly all big storage tanks which is fabricated in the field with metal sheets , these tanks to be calibrated with laser devices for proper volume calculation at every level , as the buckling of any metal Sheet will lead to a big volume difference , that's why laser

apparatus used to detect every sheet shape and every layer of the tank volume proper and accurate volume calculation.

-Second way for the other ISBL tanks, vessels and drums levels to be calibrated by the commissioning team by using the pre-mentioned tools by following steps:

1. We have to calibrate the Rotometer and micromotion water flowmeters for determining the correlation factor.
2. Connecting both flow meters in series to water supply source with manual valve, then using standardized volume 1000 liter drum we open the valve of water to flow through the flowmeters to the drum , with determining the actual filled quantity of water in the drum , and we compare it with the reading totalized by both flowmeters we can detect the difference, for example if we filled actually 90 liter and reading is giving 100 liter so difference will be 10 liter every 100 liter reading so correlation factor will be 10/100 or (0.1 of reading volume) this will be subtracted from the reading to give the actual volume for further filling values.
3. Fix the measuring tape to the capillary tube to the height of the tank to be calibrated properly from lowest point at the bottom till tank top over flow point.
4. Connect the capillary tube with the nozzle connected flange to the bottom drain flange.
5. Put the water filling hose at the top of the tank.
6. Close all other connected valves to the tank and it is better to be blinded.

7. Start the water flow till reaching the lower level indicator nozzle , then stop the water instantly, take the reading of the flowmeters after correlation as the dead level of the tank at the 0.0% level percent.
8. Then use the following scheme for calibration, without the written values this was one example we done before.

Sr. No.	Scale refferance (mm of WC)	% of level as per LT	Water meter Reading (m3)	Diff. volume (m3)	Including 2% Error	Micromotion reading (kg)	Diff weight (Ton)	Remarks
1	0	0	161.1818	0.4278	0.4364	150885	1.3730	LT bottom nozzle centre
2	165	9.42	161.7165	0.9625	0.9818	151388	1.8760	
3	330	19	162.1613	1.4073	1.4354	151826	2.3140	
4	495	29.45	162.6465	1.8925	1.9304	152294	2.7820	
5	660	39.68	163.1721	2.4181	2.4665	152800	3.2880	
6	825	50.75	163.7005	2.9465	3.0054	153587	4.0750	
7	990	60.38	164.0653	3.3113	3.3775	154067	4.5550	
8	1155	70.51	164.752	3.998	4.0780	154612	5.1000	
9	1320	81.34	165.2933	4.5393	4.6301	155138	5.6260	
10	1485	92.1	165.8061	5.0521	5.1531	155638	6.1260	
11	1650	100.05	166.3345	5.5805	5.6921	156152	6.64	LT top nozzle centre
	Notes :							
	1) Water meter initial reading :		160.754					
	2) Micromotion initial reading :		149512					
	3) LT range :		1650					

--at last record and report to whom is responsible for calibration data collection , you will need for further operation calculation, and monthly material consumption.

6-Rotating equipment commissioning:

►A-Activity definition:

-Rotating equipment preparation and commissioning for start the first load rotating mission is too critical, the vendors who supplied with the attendance of the contractor , owner teams are a must for proper handling such equipments.

-Rotating equipments as we explained before , it must have a motor connected with special static and rotating parts all are assembled in pre-commissioning and now the first trial.

-there are some equipments can run with water for trial other like blowers and fans will be tried directly with air ,and agitator will be tried with water at different levels, let's go.

►B-Tools needed for this job:

-Electrical measuring tools for motor,

-Vibration measuring tool,

-Specified oil & greasing,

-Tool kits for every team.

●How to commission centrifugal pump:

1) All pump parts to be assembled and reported properly
2) Specified Oil for the mechanical seal to be filled as per mechanical seal plan and pump function.
3) Nitrogen or cooling water for sealing checked ok.
4) Check filters or suction strainer are erected in line and cleaned properly.
5) If the pump is running by using of belts , check belts aligned and fixed properly.
6) Check the net positive suction head required written on the pump, and check the available level in the tank.
7) Pressure gauge to be erected at the pump discharge.
8) Check pump signal is connected to DCS or not yet.
9) Firstly for centrifugal pumps before starting open the suction valves and line the pump up, then vent the air from in line filter vent or from gauge vent, and assure there is no any trapped air inside before running the suction opening the suction, water only must come out.
10) All discharge way valves to be lined up except the one after the pump directly keep it closed.
11) It is better to start by tank to tank circulation (same tank).
12) Try starting the pump now from the field.
13) If pump motor started so check the motor voice attitude, and the vibration status.
14) Check the pump discharge pressure once then slowly open the discharge valve, and small opening at start check the pump attitude and the water flow to the tank top.

15) If everything is ok, so again adjust the discharge valve for normal opening and again check the pump attitude noise and vibration.

16) Check the sealing consumption, oil and cooling water all are ok , or something is missed .

17) If you heard any vibration call directly to mechanical team, and if required directly stop the pump.

18) Vibration has a lot of reasons like:

A-Suction head problem, may be liquid level is low, or any strainer /filter chocked.

B-Air bubbling in the suction ,try to release from the pressure gauge vent.

C-maybe from motor side check all body vibration , and mechanical team will define the responsible position.

D- Maybe from sealing problem.

E-may be suction or discharge valves not properly opened , check both flows.

F-may be because if improper alignment (misalignment) , shafts aren't connected with accurate axis .

G-Mechanical team are required to decide to stop or to continue.

19) Vibration also has a bad results:

A-It may damage the sealing.

B-it may cause misalignment.

C-It may cause pump decoupling or belts damage if there.

So vibration source must be detected and attended properly.

►other important note to be proper known, that every pump has scheduled change over , this schedule to be applied firmly and must be recorded clearly , for proper operating and maintenance history for every pump, and here we will explain the change over history for any centrifugal pump online,

1-Firstly, the stopped pump check status , ready for running mechanically , electrically and instrument is ready ,check ok.

2-then line up the suction line from the tank bottom slowly.

3-take the vent from point higher than the pump at filter vent or from pressure gauge.

4-start the standby pump from the field not from DCS for proper observing, then open the discharge valve slowly ,to get the proper discharge pressure, in parallel close the other pump discharge valve slowly.

5-if pump is running properly and no hammering or vibration so go on, and close the discharge of the other pump then stop it and adjust the discharge pressure of the running one. Observe the pump function is properly done, then leave it running till next change over.

►For Positive displacement pumps the stroke and the frequency will be adjusted by mechanical team, and this type of pumps aren't running with closed suction valve, it has to be lined up totally then start.

7-Fluid circulation and raw material receiving

►Liquid circulation mode for stationery equipments, like cold circulation mode for distillation tower or IDLE mode for stripping column , this circulation simply done by water in the sequence of

1-First start the feed pump to the Column and feed with low flow rate and fill the bottom sump to the recommended level.

2-start line up the bottom pump in circulation mode to tower feed point, and once level achieve stop the feed pump and continue with circulation bottom pump, and from time to time check the clearance of the water at the pump filters , if not clear so use fresh clear makeup water feed to the tower and bleed from the drain, till clear water achieved.

3-start filling the top reflux drum in tank to tank circulation mode and bypass the coolers and the condenser till further start up.

4-some times water not permitted to be used in the IDLE circulation mode of the tower so , we can use the cold feed material or whatever the recommended material by the technology supplier.

►Fans can be tried after mechanical and electrical preparing finished , no other restrictions as no suction or discharge .

►Rather than Blower which must be properly ducts loop lined up for avoiding vacuum generation and harms the ducts bolting or cause buckling and damaging.

►Compressors are different systems with more other details like sealing and cooling of the compressor parts or cooling and storing of the gas/vapor flow, every compressor has its own procedure for starting up and also if there is more than one compressor lined up in parallel or in series this to be properly lined up not to damage the compressor parts.

►in petrochemicals industries Vacuum liquid ring compressors are widely used , this type of gas/vapor pumping system has a definite sequence to be followed strictly like following:

1-Seal Pot/drum to be filled with the sealing pumping liquid.

2-Sealing liquid cooler to be lined up from both sides sealant and cooling sides.

3-Line from seal pot to the compressor to be lined up.

4-suction line to the compressor to be closed at first.

5-sealing liquid pump circulation from drum to the cooler and to the compressor then to the drum lining up to be done

6-circulation line the suction and the discharge of the compressor to be opened

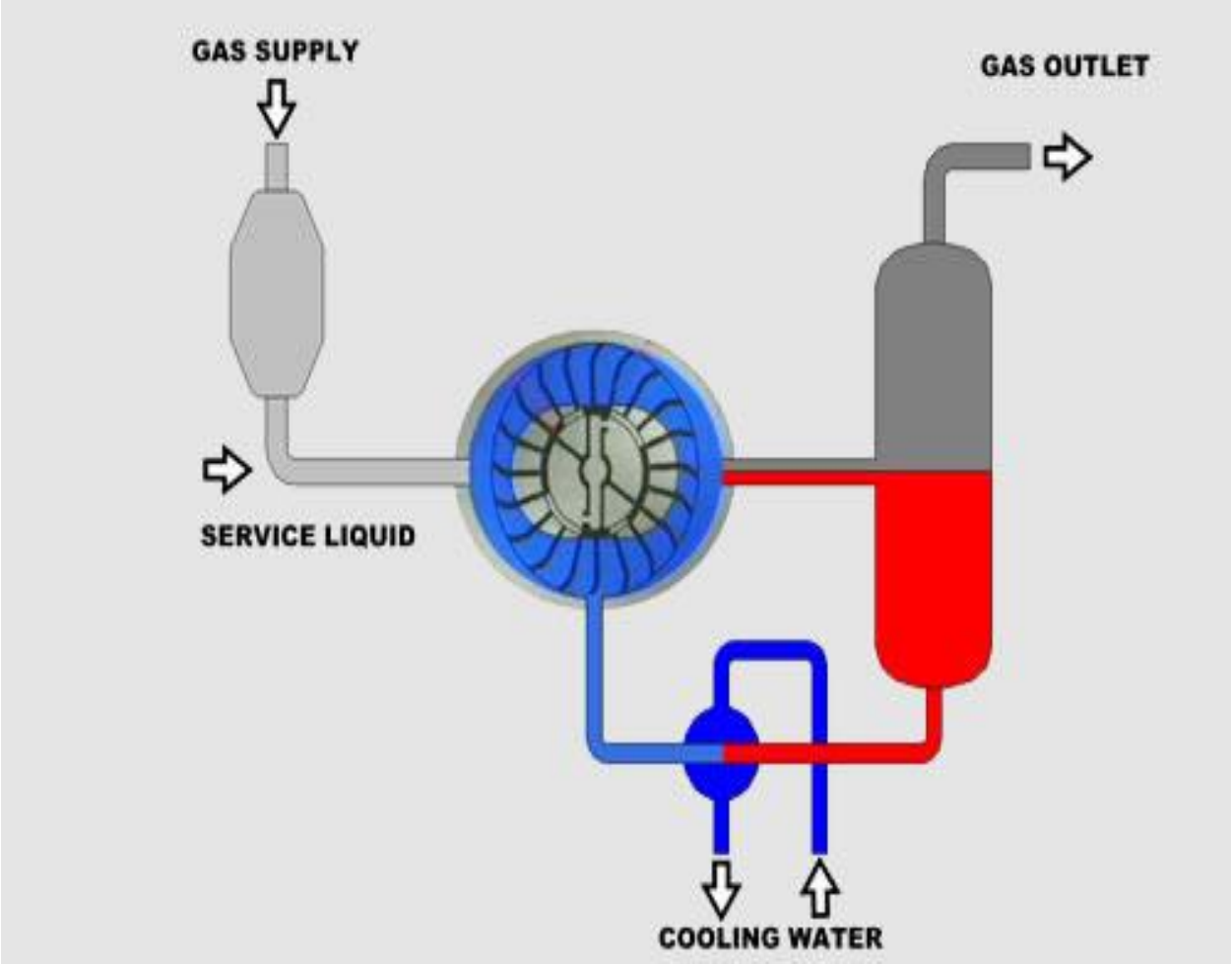
7-The pressure switch of the sealing drum to be checked ok then start the feed and bleed of the sealing liquid to and from the drum.

8-keep the level around 35% then start the compressor , this will lead to sealing level increase and after this the drum pressure will be stabilized between circulation and vent header by automatic valve.

9-then slowly open the suction line , and throttle the circulation manual valve.

10-open the suction totally and start header to header gas/vapor delivering.

11-observe the outlet temperature and adjust as per process technology recommendation avoiding auto polymerization.



8-Heating the system and hot bolting:

A-Activity definition:

●For some processes like Reactor indo thermal reactions, other distillation and stripping, cracking and coking and evaporators applications , hence heat is the main issue for these process users.

●And thus highlights and illustrates what is the heating system importance in any petrochemicals or refinery plants.

●As usual the heating is performed by many ways one of these ways is steam providing system with different range of Pressures and temperatures which varies and distributed as per the process functions and requirements.

● Or heating is provided by circulation of the cold material in heat exchanger by using other out let heated flow interchanger.

●Or heating by using another preheated medium, circulated between a fired heater and users in different plant areas.

We will explain the main heating system which is more common in petrochemicals plants, third one heating type by using preheated medium you can also observe that Steam is preheated medium coming from boiler and distributed all over the plant areas and users.

►Heating by Fired heaters:

-Commissioning Procedure:

-The main factors to be studied for any heater commissioning and start up are:

1- The flow rate of the liquid to be heated.
2- The inlet temperature of the flow to the furnace.
3- The outlet targeted temperature as per the plant requirements.
4- Then studying the other side for the burner used flammable material, what is the flow required for such quantity of heating requirements.
5- Burner start up sequence.
6- Burner flame control cascaded with the liquid flow rate.
7- We are explaining liquid tube heaters type.
8- Further gradually temperature increasing.

Explanation:

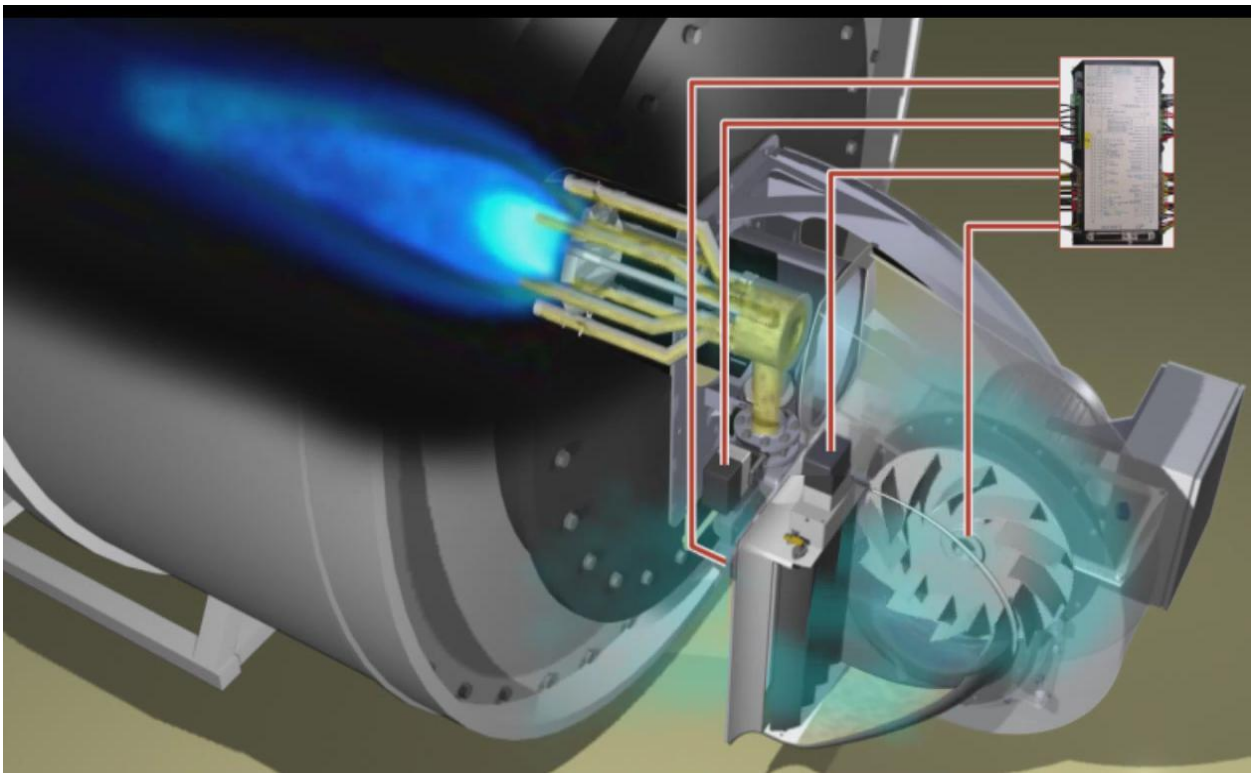
-The first step is to check the stock for both heated material and the fuel side.

-Check required pumps for circulation status.

-Start liquid cold circulation to the heater and adjust the minimum flow at starting.

-The filters and strainer of the liquid first circulation to be properly cleaned and changed till pumps normal Discharge pressure reached.


MONOBLOCK BURNER N10.14000 GL-EF3
Industrial dual fuel burner
operating in oil or gas
Output (1 750) 10 000 - 14 000 kW



-Burner checking and startup sequence like following:

1- Flow in the tubes is healthy.
2- All burner parts checking passed successfully
3- Setting the fuel /air ratio
4- Primary air blower startup.
5- Secondary air dumper open.
6- LPG + Spark + flame arresting starting
7- Fuel starting and Flue gas to stack started.
8- Primary air and secondary air blower and damper adjusting as per flame volume and heat required.
9- Start Temperature set point with the minimum limit and normal liquid in tube flow rate.

10-

Start the secondary user pumps circulation, like coils pumps , evaporators tube side or heating jacket pumps, this all must be pre-circulated at cold status for loop cleaning and filtered clear flow, second time the heated system starts if again checking happened so isolate and change over, till all secondary loops service flow stabilized ,

11- Then start temperature increasing by increasing the set point of the outlet temperature to the burner PLC and increase by a very slow and gradually temperature difference.

12- Finally the primary loop and the secondary loops will take some time may be one two weeks for achieving the temperature and getting ready for startup & last step is hot bolting by the recommended hot bolting torque for all flanges for primary and secondary system.

9-Startup sequence trial on water and nitrogen& raw material feeding for startup:

A-Activity definition:

►As per our course headline here we will talk about start up sequence in general about the petrochemical industry and afterwards we will explain two types of the petrochemicals (reactor).

-Here we reached to point that plant is commissioned and every equipment is tested separately and its attitude and function performance checked on running water system, the plant heating and cooling services now are running now but no heat consumption started as no (reaction) or , polymerization started.

-Our plant DCS now all sequence logic setting up done for every controller at all positions of the plant, the DCS operators are proper trained on every unit operation starting and circulating and shutdown sequences and how to treat with equipment different attitudes ,

-For any troubleshooting happened in the field for any equipment or any parameter proper communication between DCS and field to be assured by proper reaching and informing facilities.

-The control room are the main issue for start up as the following for the parameters fluctuating and controlling will be sharply differ from time to time and from level to level, meaning of the

real power consumption will increase and all motors will be loaded by the row ,intermediate and final products.

-In presence of technology supplier and main contractor of the project usually the plant startup sequence started.

-First step for any polymerization process is the preparation stage, all raw material will start feeding only when all are prepared as per specification , not only this but the raw material stock will guarantee the running of the gradually capacity increasing from lower capacity of the plant till first performance test.

-Additives schematic detailed preparation procedure to be educated properly for operators who are responsible for this part in the plant, then additives and raw materials sampling to be taken and results to be followed with the qc lap for all raw material it must be same to the standard specifications provided by the technology supplier.

-If all additives are prepared and samples of all raw material is accepted so, we proceed for next step the feeding to the plant.

-Some Petrochemicals polymerization plants are starting with the monomer preparation stage , and the monomer may be stored or directly taken to the oligomer stage then to polymerization stage.

-Starting with the monomer may be unit in the plant or another plant specified for this monomer production.

-The “know how? “ procedures for the monomer production is sequenced and half production rate started then other unit start for oligomer production , the sampling frequency of the dummy

batch is a high frequency rate as 2 or 3 samples per hour at every sample point of the stage.

-As we are starting new feeding to the system so the motors load , sound and the vibration will be different, and this to be checked healthy or not during the first start up.

-Startup with low flow rates will be controlled from the field and DCS together not from DCS only as all manual valves of the plant will be adjusted manually from the field due to low capacities, like coolers , and heat exchangers , pumps discharge flow rates , tower top reflux temperature and flow back to the tower top, and many other parameters DCS can't fully control alone without the help of the field.

-Agitators with variable speed has level control cascaded switch this level switch will not permit the agitator to start at lower levels as per the interlocks done.

-Some pumps filters will be affected in highly rate of change over and this to be followed by active operators.

-DCS interlocks to be modified with the technology supplier to bypass some limits at start up and the clamping of the automatic valves ramping to be done but with the technology supplier.

-From unit to next the field Engineers and operator must follow all the parameters which pre-plotted for all equipments and controllers during the increasing of the rates , levels and heat supply or removal requests from different users in the plant.

-Till reaching to the polymerization stage , where the reaction rate and conversion is low and started to increase , if this is

permitted to sample online ok , if reactors not designed for online sampling like batch reactors so keep first batch finished and during blowdown start the sampling

10- Sampling and parameters tuning for commercial standardization:

A-Activity explanation

►Here we reached to the first product stream, and as usual for any plant there must be tuning period after start up , the product stream is going to off-spec silos as parameters not standardized yet.

-The product stream is continuous at most op plants , maybe there is any other batch processed units inside the plant but usually product finishing and conveying to the storage silos are continuous .

-The standardization of the parameters is depending on the specifications results coming from the QC lab for intermediate products and for the final product.

-with studying the samples results and the process parameters ,with the help of the technology supplier we can enhance the product specification gradually.

-in the petrochemicals industry not only the process parameters are achieving the target product specification, but also the equipments efficiency, all rotating and stationary equipments changeovers , Predictive& Preventive maintenance, operation normalizing and daily checking and job schedule to be followed strictly without passing any job without scientific reason, all these

parameters and procedures will protect your product enhancement from troubleshooting and properties fluctuating.

11-. Post commissioning &Process modifications and SOP setting for capacity enhancement:

A-Activity description:

►After normalizing all DCS parameters and setting the standard limits for all intermediate products and final product, the process units equipments attitude studying will lead to discover that there is some instruments, valves, Gaskets &Piping aren't properly working, or working properly till a definite limit after that its performance not perfect, so these instrument ot modifications may be suggested by the technical support team (mechanical, Process, Electrical and Instrument)Engineers.

●The studying for the process trends at the first startup will lead for more information about all equipments best operating way.

●The SOP or standard operating procedure for any equipment or unit is given theoretically by the technology supplier, but actually most of plants need some modifications on these procedures, as no plant is 100% typical to another of same technology , may be construction area, or construction materials or the way of the construction of any equipment itself ,any or all of these conditions makes the SOP need some modifications from plant to plant.

●SOP of any equipment is studied and modified by the operation team, as they are the most person who are observing the troubleshooting of all the plant, so for modifying any SOP .

● All equipments of the plant are listed by area with the tag numbers and steps of best operating condition, from upstream to downstream & how to avoid mechanical or electrical failure due to any miss-operation , justifying the faced troubles and the best troubleshooting procedures for any part of the equipment, all details are under microscopic study.

●Power failure emergency plan and temporary SOP are pre-planned , how the troubleshooting team can arrange the emergency plans for the plant downstream units ant all equipments how to be saved from any catastrophic conditions accelerations, the emergency plan are giving every member of the team a definite job from the power failure starting, without instruction, every field operator in every area must be pre-trained for such emergency jobs , this is a very important point to be planned and studied from the operation and production managers and with the most safe way without any irresponsible adventure from any member of the team.

●after running the plant for a definite period sufficient for parameters standardization, some plants are doing the post commissioning by planned partial shutdown or total plant shutdown it depends on what is the post commissioning plan and what is required to be modified.

12-Performance check for lower, normal &maximum capacity.

A-Activity description:

►Comprehensive system assessments using advanced data collection tools and methods coupled with sophisticated modeling techniques provide the blueprint by

●Identifying opportunities to reduce energy usage of major systems and critical equipment

●Diagnosing the root cause(s) of underperforming systems and premature equipment failure, regardless of OEM or type

●Identifying opportunities to improve operator safety

●Developing solutions for chronically problematic equipment using life cycle cost (LCC) projections

●Determining actual system head curves for re-rating or replacing existing pumps

Regardless of plant size, empirical evidence reveals that 5% to 10% of the installed pump base will consume 40% to 50% of the maintenance budget due to short mean time between failure or poor performance. Whether the causes are hydraulic or mechanical, a disciplined, methodical program to eliminate bad acting pumps will result in significant and rapid savings. optimization assessments identify the pumps that most negatively affect the Petrochemicals operating expenses. This typically entails:

• Analysis of energy utilization rates to identify the highest energy usage pumps

• Confirmation of current operating characteristics of identified assets

• Audits of equipment reliability records to determine which pumps have the highest incidences of unscheduled outages
• Reviews of maintenance methodologies (i.e., run-to-failure, preventative, predictive, etc.)

• Analysis of other items such as LCC database, parts inventory, operational issues, etc.

► Cooling Water System Assessments:

Cooling water systems are complex pipe circuits with very long piping runs. Performance and energy improvements can be obtained by a full water piping assessment, optimizing pressure losses. Flowserve engineers use advanced hydraulic modeling tools and life cycle costing methodologies to evaluate the system using actual performance data. They then develop corrective action plans that maximize plant output without compromising equipment efficiency or component mean time between repair (MTBR).
Assessments can help plant operators identify and rectify the root causes of problems such as:

●Low circulating water capacity

●Inefficient condenser performance

●High condenser backpressure

●Low component MTBR

●Insufficient cooling water

●Elevated energy consumption

Chapter 3

Petrochemicals Reactors Types

& Process Examples.

Content

1-Petrochemicals Reactors Types:

►Explanation:

●Polymerization reaction is simply a reaction between small monomer molecules at specific conditions will proceed till definite polymer chain length.

●Any polymer has different grades which depend directly on the monomer molecules number in the chain of the polymer, and the shape of the arrangement style of monomer molecules in the same polymer chain.

●Polymerization (petrochemicals)Engineering is the science field where all the required conditions for producing a definite polymer with definite specifications, is applied by translation of the chemical reactions from lab experiments to commercial production rates, with the selectivity of the proper equipping and proper control system for the required process.

●The reactants and the additives are other issue, that must be determined properly as per the physical and chemical specifications required for the final polymer properties and applications.

●Reactors are the most critical equipment in the polymerization process, as all main conversions of the reactants are going on inside this equipment, that's why the selectivity of the reactor and its process control system needs more studies, as more reactants

with more variables have to be mixed , reacted and terminated at definite specifications.

●Here we will discuss the main known polymerization reactors types as per the reaction process proceeding:

1. **Batch Reactors.**
2. **Continuous Stirred Tank Reactors (CSTR or Mixed flow).**
3. **Plug Flow Reactors (PFR).**

●Where every reactor has different process application has its specifications as:

1-Batch polymerization reactors:

-Used for manufacturing of expensive products.

-Typical for small-scale operations.

-Used if continuous process isn't applicable.

-Used for higher conversion rates.

-Useful for testing new process conditions & variable products from batch to batch.

►Mass balance for batch reactor:

$$F_{A0} - F_A + \int_0^V r_a dV = \frac{dN_a}{dt}$$

Where: F_{Ao} is the molar flow rate to the reactor
=Conc. X V

F_A is the output molar flow rate from the reactor.

V volume of the reactor.

r_a reaction rate.

$\frac{dN_a}{dt}$ Accumulation rate

►This is called the General Mole Balance Equation or (GMBE)

Which is used simply for calculating the reaction rate , or reactor volume or the accumulation rate whatever the available variables.

►In batch process :

F_{Ao} & F_A equals zero

As there is no any input or output flow rates during the polymerization reaction.

And V (reactor volume is fixed for constant batch)

So $r_a \times V = \frac{dN_a}{dt}$

►And also the reaction time is fixed constant for batch reactions so the equation will be like

$$r_a \times \mathbf{V} = \frac{dN_a}{t}$$

Or $r_a \times \mathbf{V} \times t = dN_a$

And for batch reactor r_a and dN_a will be minus as the reactants are disappearing from the reactor

And the accumulation rate dN_a will be integrated from dN_{A0} to dN_{Af} as in batch reaction accumulation is increasing like following.

$$-r_a \times \mathbf{V} \times t = \int_{dN_{A0}}^{dN_{Af}} -dN_a$$

Or

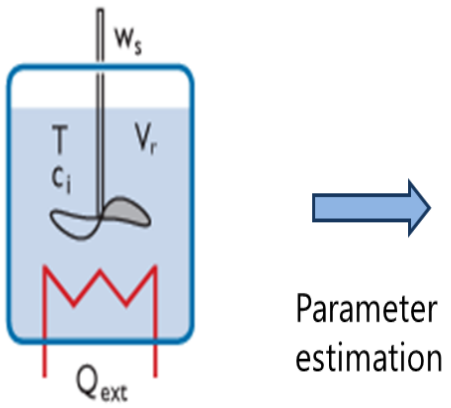
$$-r_a \times \mathbf{V} \times t = \int_{dN_{Af}}^{dN_{A0}} dN_a$$

► And finally the batch residence time equation & called Batch reactor sizing equation will be :

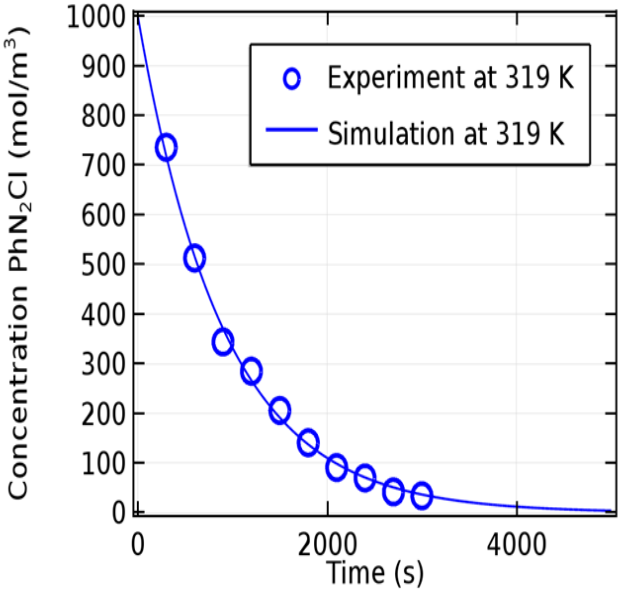
$$t = \int_{dN_{Af}}^{dN_{A0}} \frac{dN_a}{-r_a \times V}$$

►This example for batch reactor reactants disappearing by time:

Lab-scale ideal batch reactor



Parameter estimation



2-Continuous Polymerization Reactors:

►It is called Continuous stirred tank reactor (CSTR)

Or mixed flow reactors.

-Continuous Stirred Tank (CSTR) Reactor:

●At steady state it is selected for polymerization processes at which:

-the reactants concentration starts at reactor start up to decrease then again it continue constant with the time.

-the accumulation rate equals zero.

-the reaction temperature is constant.

-concentrations of reactants are direct proportional to reaction rate.

-Reaction rate & K value is direct proportional to the reaction Temperature.

-This called Steady state reaction as the reactant concentration isn't changed with the reaction time or with the reactor length or radius it is reached to the operation concentration after entering the reactor inlet then acts as steady state.

►General Mass balance equation GMBE:

$$F_{A0} - F_A + \int_0^V r_a dV = \frac{dN_a}{dt}$$

And for Polymerization reaction in CSTR:

- M_0 is monomer concentration input stream to reactor.
- M is monomer concentration output stream from reactor.
- V^0 is volume flow rate input = output as accumulation is zero.
- V is the reactor constant volume

So: mass balance for monomer

$$\mathbf{M_0 \times V^0 - M \times V^0 + r_m \times V = (accumulation)\ 0.0}$$

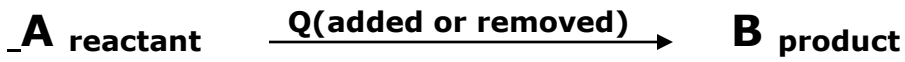
Where $V/V^0 = t$ residence time

So $M_0 - M + r_m \times t = (accumulation)\ 0.0$

$$t = \frac{\int_{M0}^{M} M}{rm} = - \frac{\int_{M}^{M0} M}{rm}$$

- using this equation for determining the residence time of the monomer reaction in the CSTR ,depending on the monomer disappearing rate.
- there another calculation for the polymerization rate according to the polymer initiation and propagation rates .

●also we can calculate the CSTR reactor heat balance



[Reactant Energy flow in +Product Energy Flow in –Reactant Energy flow out –Product Energy flow out $+Q^0$]=Energy accumulation

$$([F_{A0} * H_A * T^0]+ [F_{B0} * H_B * T^0]-[F_A * H_A * T]-[F_B * H_B * T]+ Q^0_{\text{added or removed}})=\frac{d[(NHT)_A+(NHT)_B]}{dt}$$

●H enthalpy

●F molar flow rate

●T temperature

●N number of moles(concentration accumulated)

●Q^0 heat duty continuous removing from the reactor by cooling or heating .

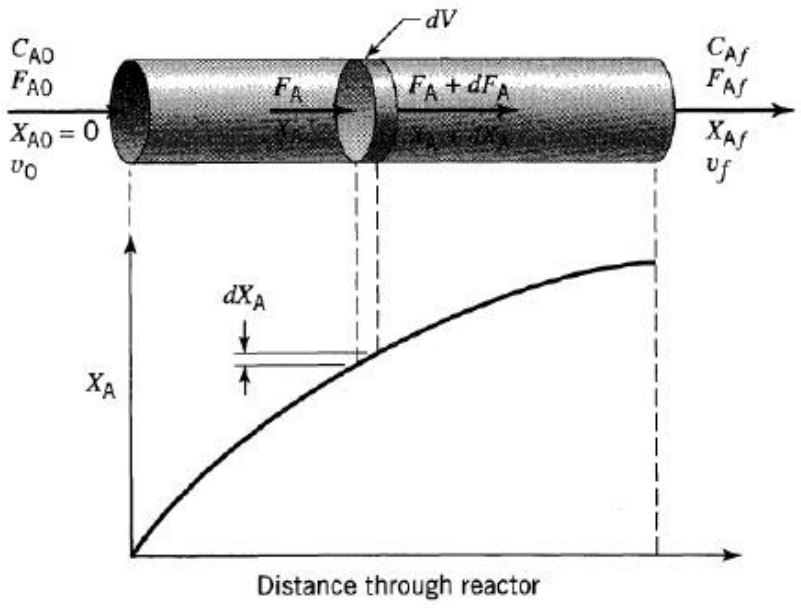
3- **Plug Flow Reactors (PFR):**

-Plug flow Reactor is the third polymerization common reactor which its reaction proceeds: by axial reaction rate increasing with the difference in the reactor length.

Plug Flow Reactor

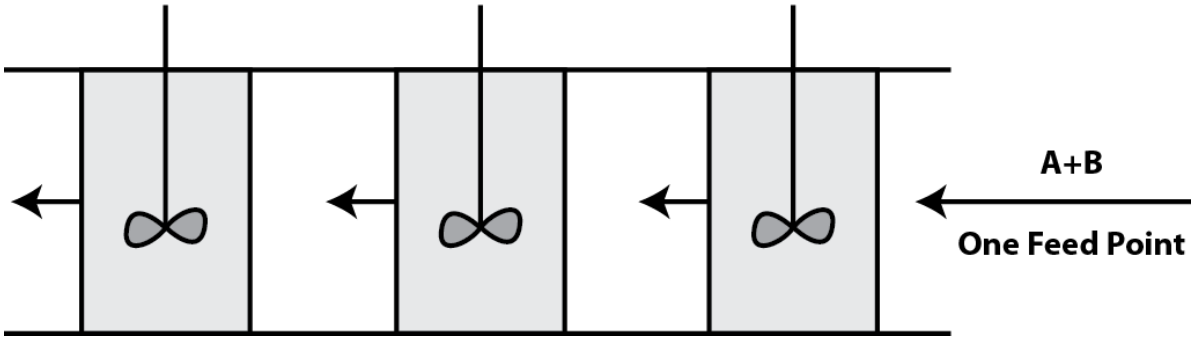
Plug Flow Reactor: Ideal flow reactor in which no back mixing occurs.

The composition of the reaction mixture changes along the length of reactor.

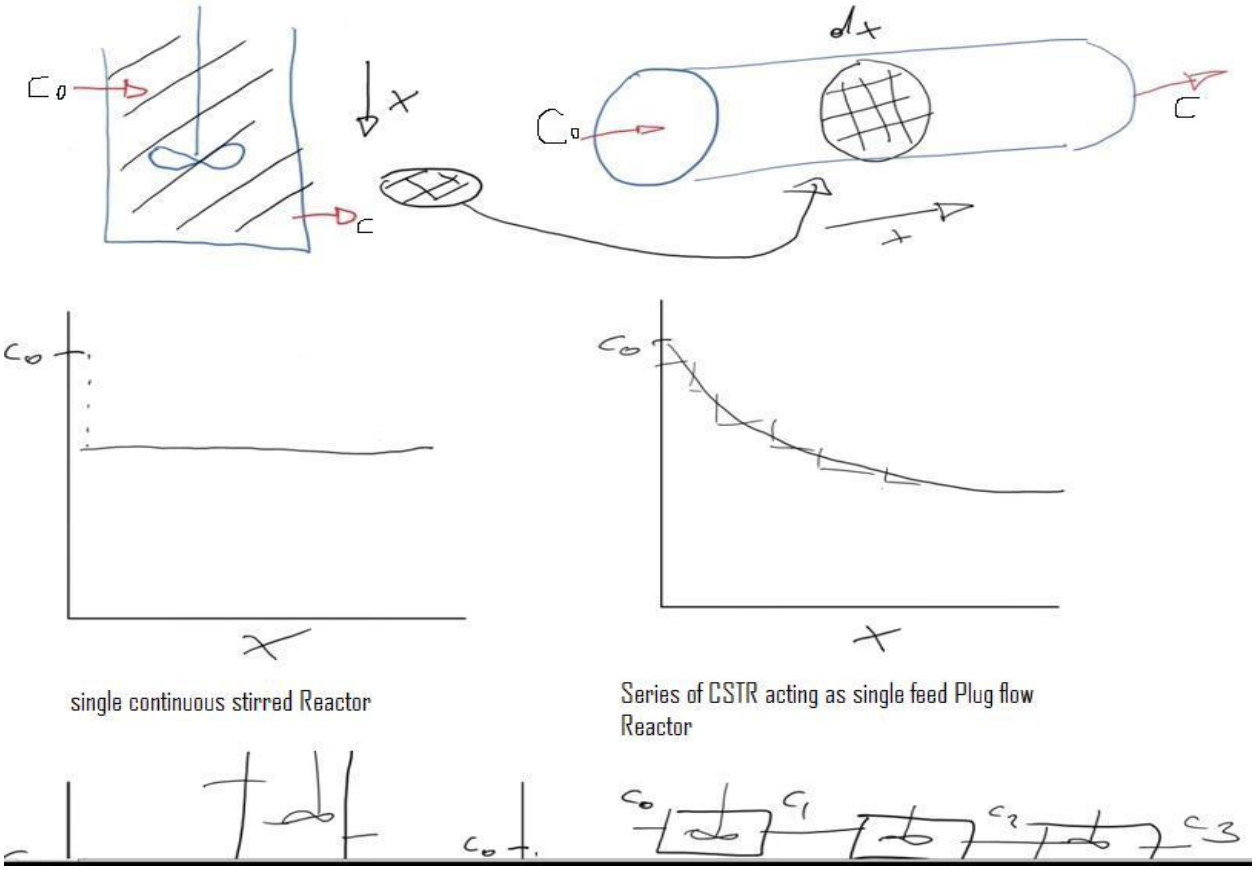


-Where some polymerization applications uses a series of CSTR reactors which scientifically is equal to one big plug flow reactor, like following.

Single Feed Plug Flow



►Series of Continuous stirred reactors (CSTR) acting as single plug flow.



►►Batch Polymerization Process

►SUSPENSION POLY VINYL CHLORIDE

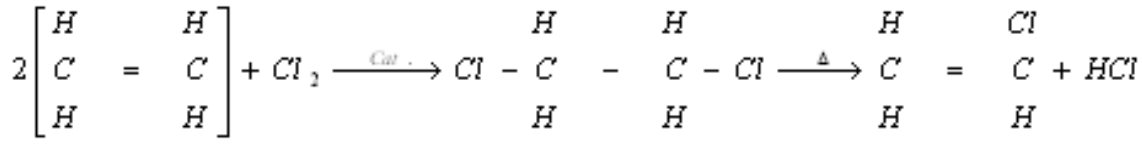
Poly Vinyl Chloride is commonly abbreviated as PVC Third most widely used Thermoplastic Polymer ,Over 50% of PVC manufactured is used in construction, As a building material, PVC is cheap, durable and easy, to assemble Annual World Production of PVC is 26 million tonnes.PVC world market grew with an average rate of apprx 5% in the last years and reached 40 million tons by the year 2016 It can be made softer and more flexible by the addition of plasticizers.

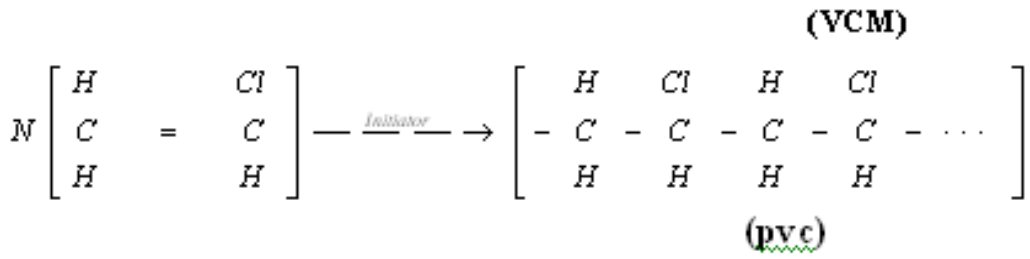
WORLD
POLYVINYL CHLORIDE PRODUCERS
(Based on 2005 Average Annual Capacities)
Company

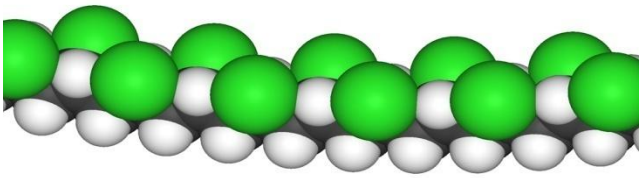
RANK	COMPANY	CAPACITY (-000- METRIC TONS)	SHARE % OF TOTAL
1	Oxy Vinyls LP	2,072	5.65%
2	SHINTECH Incorporated	2,040	5.56%
3	Formosa Plastics Corporation	1,653	4.51%
4	Georgia Gulf Corporation	1,225	3.34%
5	Formosa Plastics Corporation USA	1,192	3.25%
6	Shin-Etsu Chemical Company, Ltd.	990	2.70%
7	Solvin	905	2.47%
8	LG Chemical, Ltd.	880	2.40%
9	European Vinyls Corporation	703	1.92%
9	Ineos Vinyls	703	1.92%

►Polyvinyl chloride was accidentally discovered On two occasions, the polymer appeared as a white solid inside flasks of vinyl chloride that had been left exposed to sunlight B.F. Goodrich Company developed a method to plasticize PVC by blending it with various additives The result was a more flexible and more easily-processed material that soon achieved widespread commercial use.

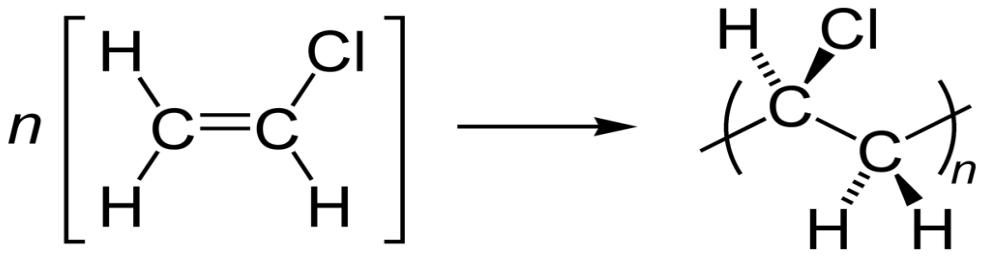
►its chemical reactions:







► PVC is produced by polymerization of Vinyl Chloride Monomer (VCM)PVC requires less petroleum than many other polymers



► Widely used production process is suspension

Polymerization VCM and water are introduced into the polymerization reactor Initiator & other additives are added to initiate polymerization The contents of the reaction vessel are continually mixed to maintain the suspension and ensure a uniform particle size of the PVC resin

Operating Temperature: 54 – 56 deg C

Operating Pressure : About 7.5 bar

The reaction is exothermic and thus requires a cooling mechanism to maintain the reactor contents at the appropriate temperature ,as the volumes also contract during the reaction, water is continually added to the mixture to maintain the suspension Once the reaction is completed, the resulting PVC slurry is degassed and stripped to remove unreacted VCM Recovered VCM is used in the next batch Stripped PVC slurry then passed through a centrifuge to remove most of the excess water

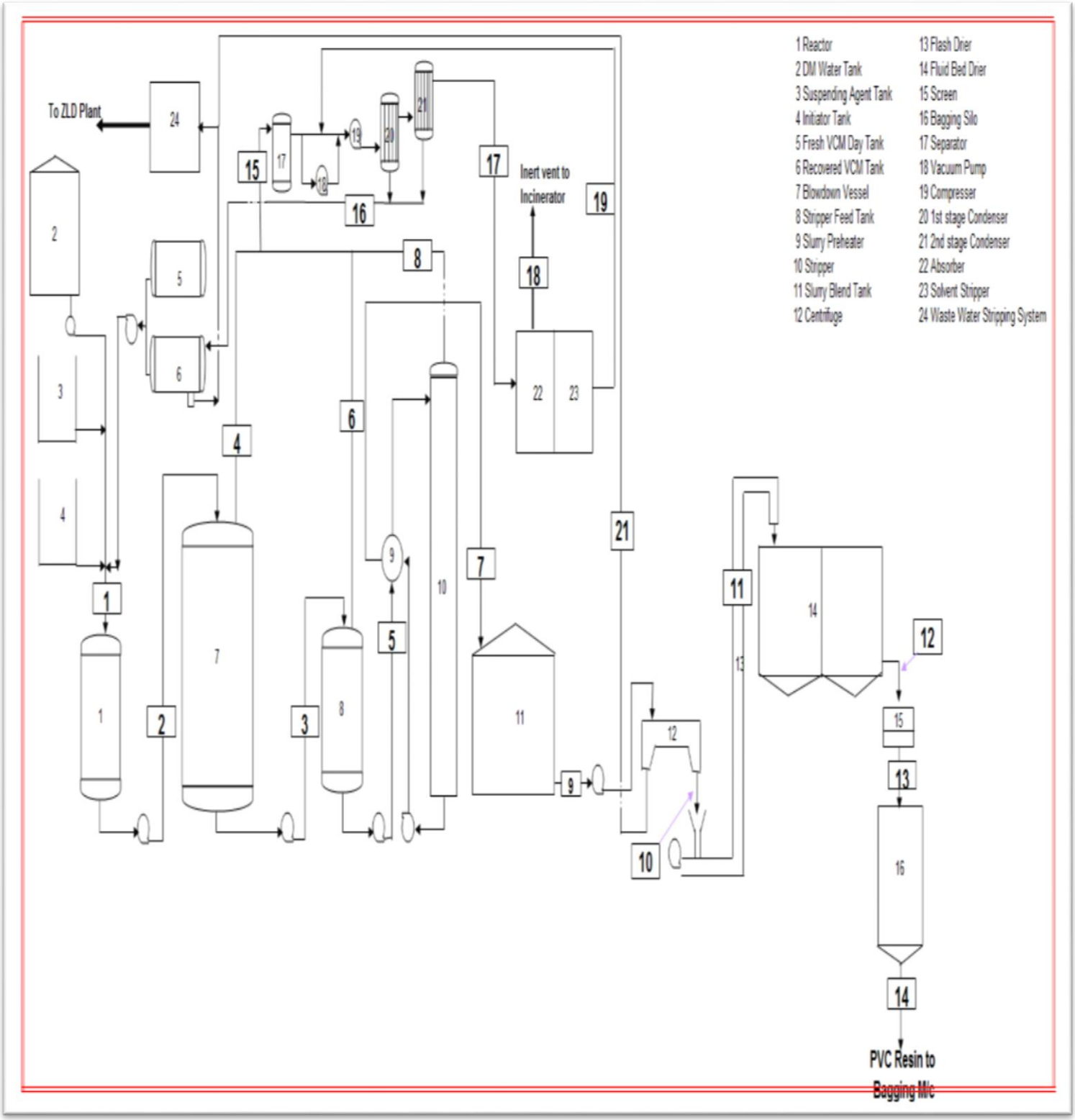
The slurry is then dried further by hot air in flash drier / fluid

bed drier and the resulting powder sieved before storage.

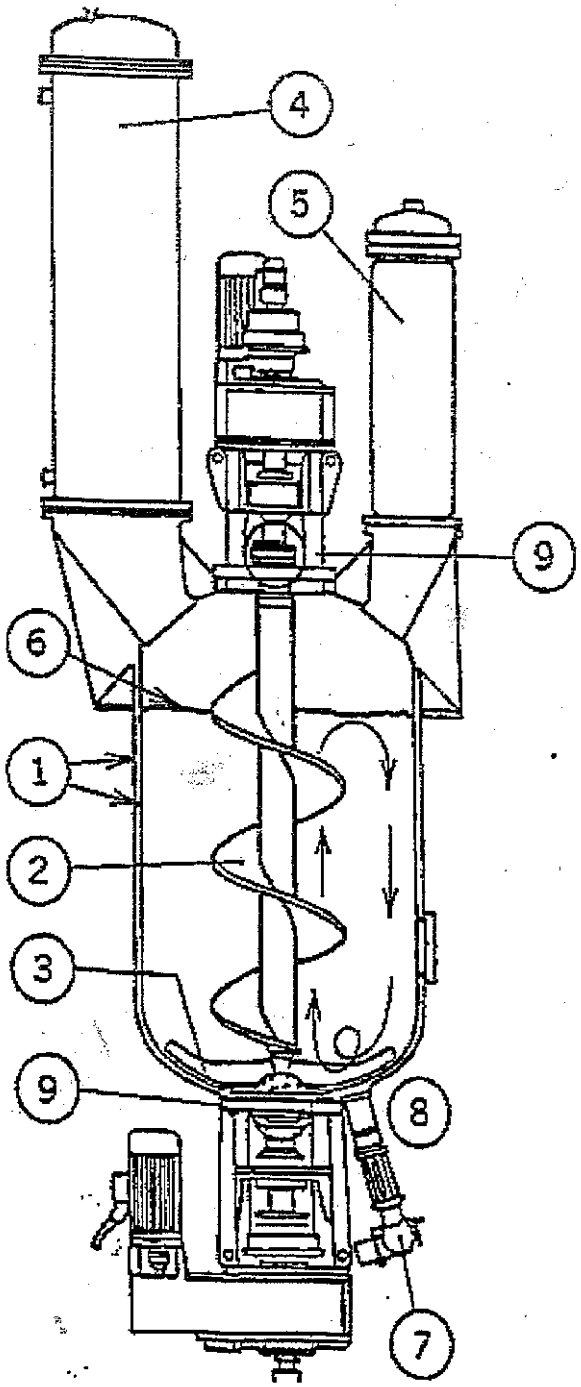
► Other production processes, such as Micro-suspension

Emulsion polymerization produce PVC with smaller particle sizes (10um vs 120-150 um for S PVC) with slightly different Properties and with somewhat different sets of applications.

►Process flow chart of S-PVC

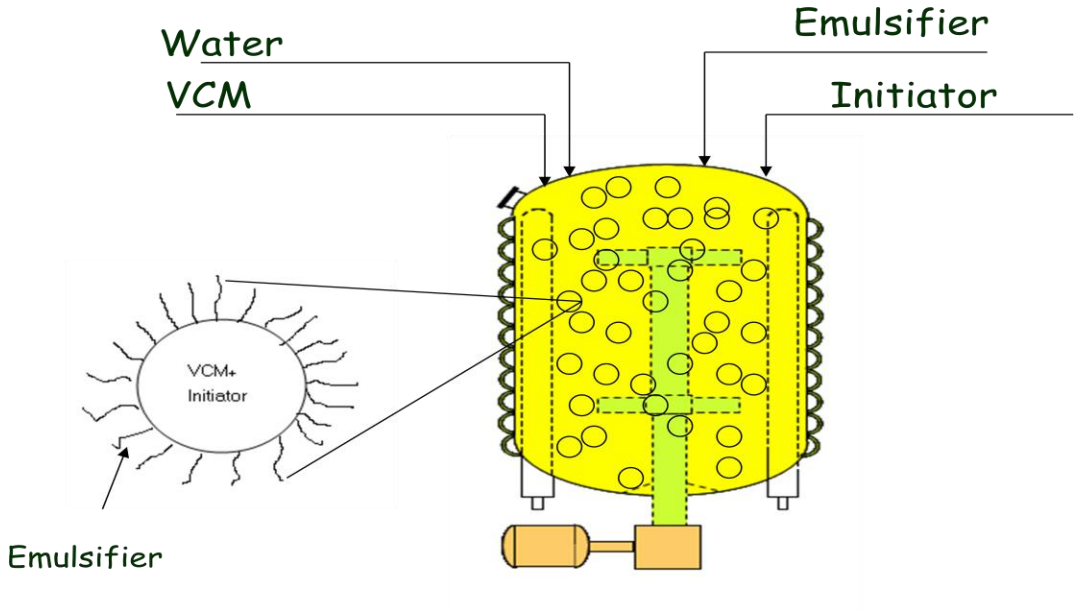


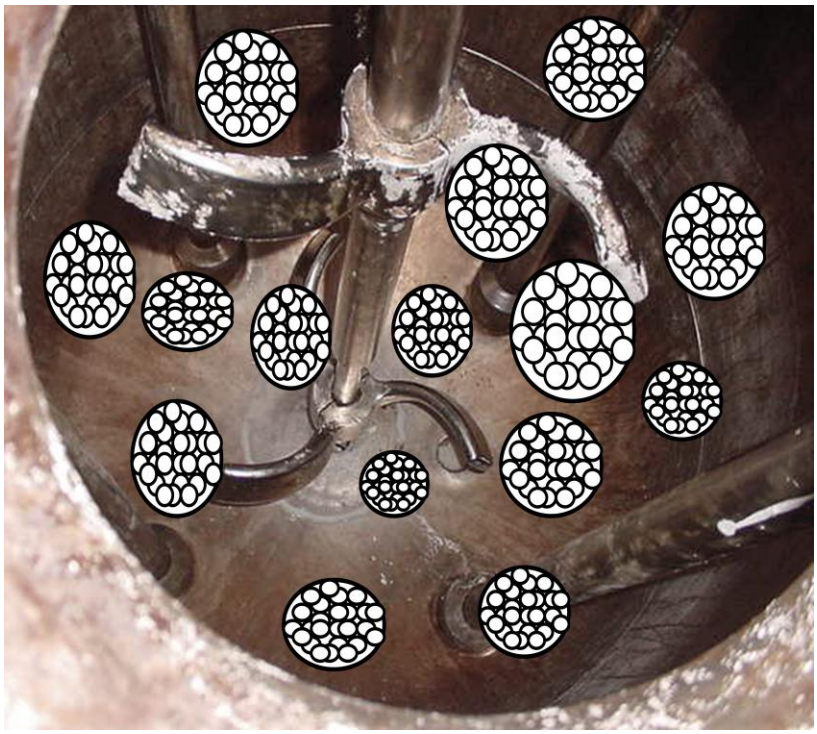
►S-PVC Batch Reactor overview:



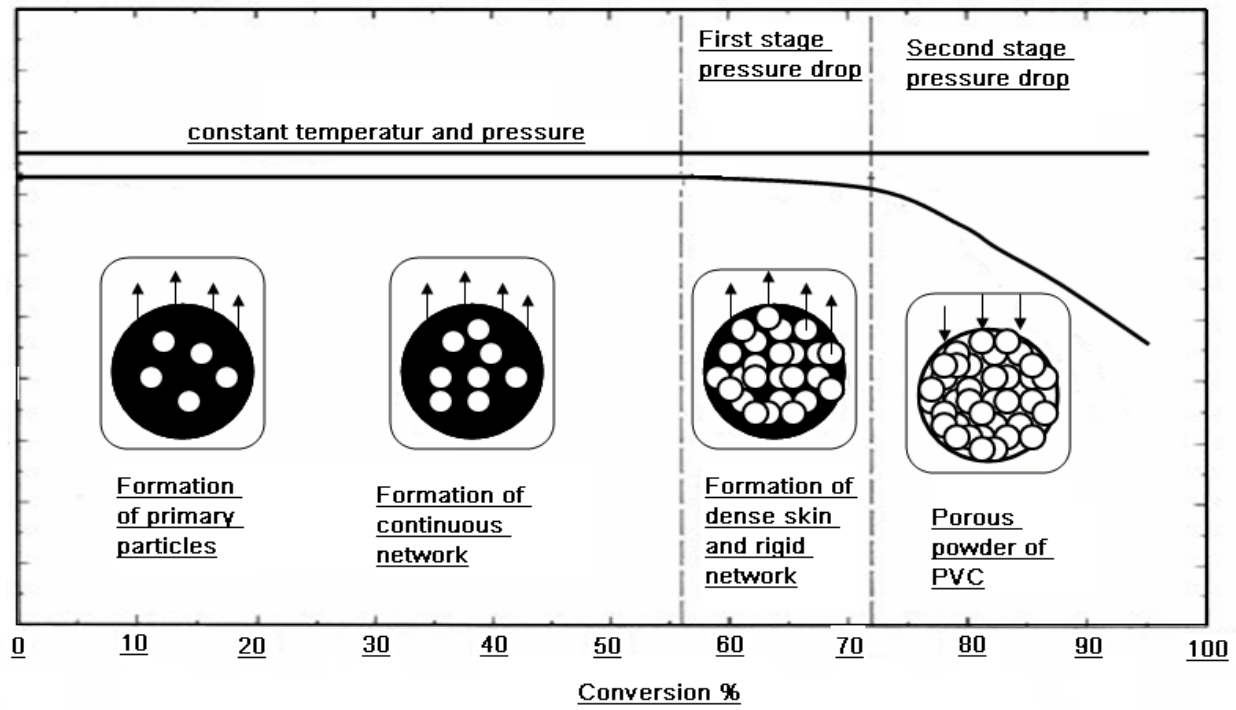
1. **Reactor Shell and Jacket**
2. **Upper Screw Agitator**
3. **Lower Agitator**
4. **Reflux Condenser**
5. **Degassing Filter**
6. **Maximum PVC Resin Level**
7. **Discharge Valve**
8. **Manhole**
9. **Packing Seal**

POLYMERISATION



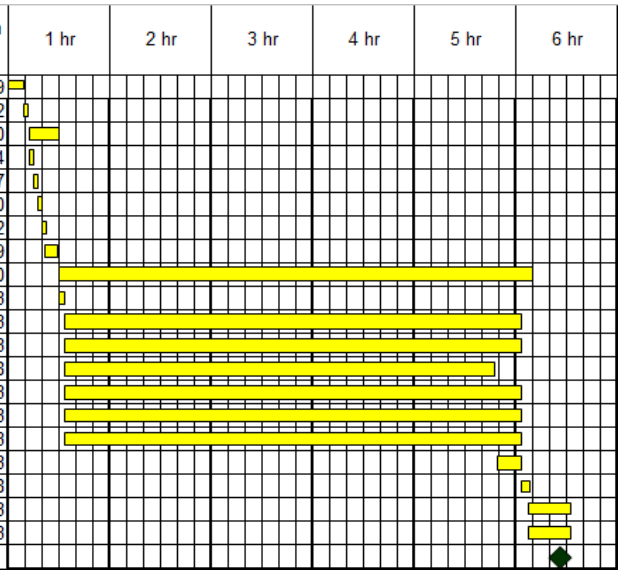


►Polymerization Attitude:



►Polymerization reaction cycle:

S.No.	Activity	Duration (in minutes)	Start Time	Finish Time
1	Cleaning & Coating	9	0.01	0.09
2	Close and Checking of Valves	3	0.10	0.12
3	Water Charging	18	0.13	0.30
4	Charging of Buffer Solution	2	0.13	0.14
5	Charging of Suspending Agent (Primary)	3	0.15	0.17
6	Charging of Suspending Agent (Secondary)	3	0.18	0.20
7	Recovered VCM Charging	2	0.21	0.22
8	Fresh VCM Charging	7	0.23	0.29
9	Starting Nitrogen (Condenser Blanketing)	280	0.31	5.10
10	Charging of Initiator	3	0.31	0.33
11	Jacket Cooling Water Pump	270	0.34	5.03
12	Condenser Cooling Water Pump	270	0.34	5.03
13	Reaction	255	0.34	4.88
14	Condenser Pr. / Temp Regulation	270	0.34	5.03
15	Temp Control of Jacket Cooling Water	270	0.34	5.03
16	Pressure Control	270	0.34	5.03
17	Auto Heating	15	4.89	5.03
18	Charging of Inhibitor	5	5.04	5.08
19	Discharging of PVC Slurry	25	5.09	5.33
20	Recovery of VCM from Reactor	25	5.09	5.33
21	Completion of Batch	333		



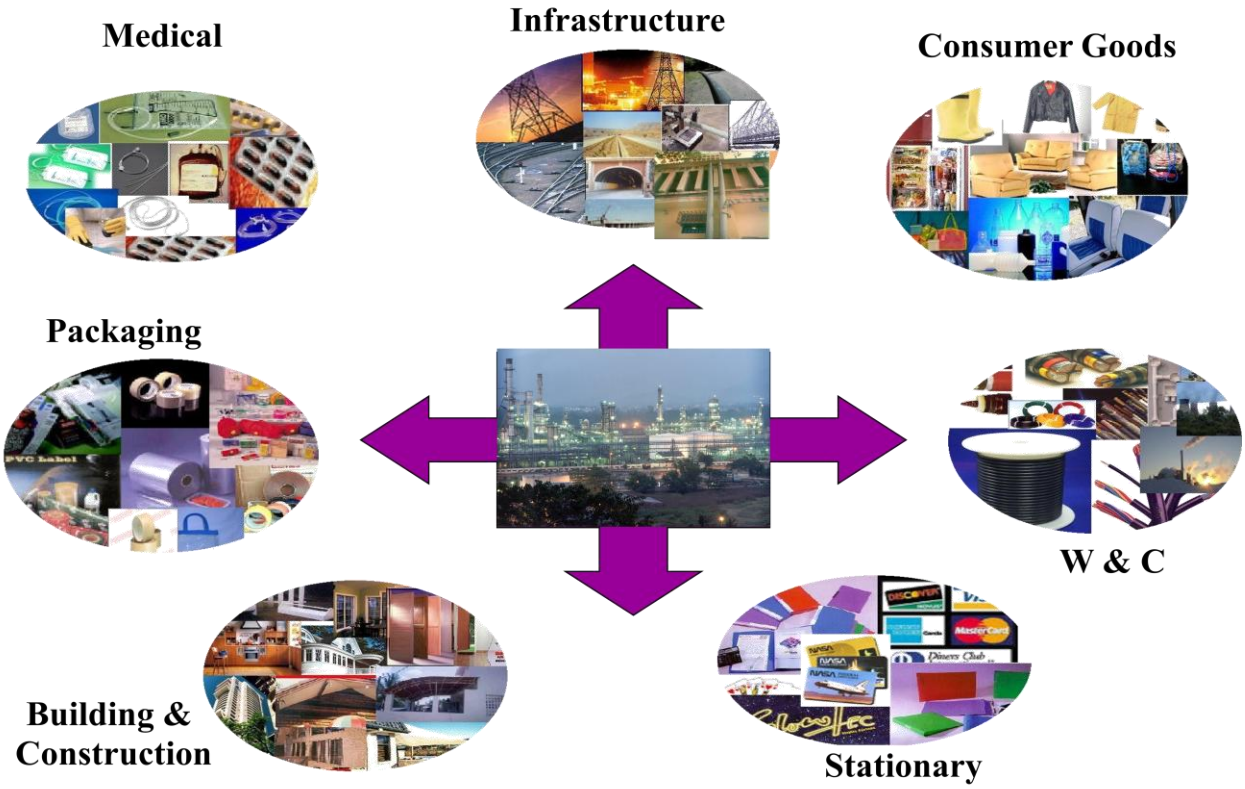
S-PVC polymer Physical properties:

Density	: 1390 kg / cu.m
Tensile Strength	: 50 – 80 MPa
Elongation at break	: 20 – 40 %
Melting Point	: 100 – 260 deg C
Specific Heat	: 0.9 KJ / (kg-K)
VCM content	: < 1 ppm
K Value	: K67
Porosity	: 0.1 – 0.4 cu.m / gm
Particle Distribution	: 120 – 150 um.

PVC's intrinsic properties make it suitable for a wide variety of applications. It is biologically and chemically resistant, making it the plastic of choice for most household sewerage pipes and other pipe applications where corrosion would limit the use of metal

With the addition of impact modifiers and stabilizers, it becomes a popular material for window and door frames.

By adding plasticizers, it can become flexible enough to be used in cabling applications as a wire insulator



Some of widely uses & application of PVC

► Unplasticized polyvinyl chloride uPVC or Rigid PVC is often used in the building industry as a substitute for painted wood, mostly for window and door frames.

► Clothing

PVC has become widely used in clothing. PVC is cheaper than rubber and leather and so it is more widely available and worn PVC fabric has a sheen to it and is waterproof. It is commonly used in coats, jackets, aprons and bags because of this.

●S-PVC Process Explanation:

-The PVC plant consists of the following 6 areas in this sequence:

1- Polyhouse area (polymerization batch reactors).

2-Blowdown area (monomer high pressure recovery).

3-Stripping area (monomer low pressure recovery).

4- Monomer Compression and liquefaction area.

5-Dewatering and Drying area.

6- Conveying ,Storage and bagging area.

1-Polyhouse Area:

In this area there are many tanks related to additives preparation and storage for feeding to the reactors.

The required additives need to be added to the reactor are :

●1-SAP or (suspending agent primary) : weak surfactant used for coagulating of number of the monomer particles and acts as a precellular membrane around this drops of the monomer and it is added with definite quantity to control both polymer particle size , and proper thermal distribution profile with the agitation speed.

●2-SAS or (Suspending agent secondary): used to determine the porosity of the polymer particle as it is making a partial coalescence when the reaction proceed and the particle starts to shrink it makes the inside structure rigid , and so pores appears .

●3- Initiator :

-For polymerization reaction there are 3 stages:

A- Initiation.

B- Propagation.

C-Chain transfer

D- Termination.

-for the initiation step the monomer is ionized by the free radical transferred from the initiator to the monomer then from the monomer to another and monomers are connected by transferring this free radical and chain starts to propagate and till a definite limit with required polymer chain length or polymer molecular weight the reaction will be terminated and chain will be formed inside the precellular membrane formed around the monomer molecules by SAP.

-Initiator has many types but the type which generally used here is alpha methyl-hexyl peroxide carbonate , which has explosive peroxide group in ambient temperature that's why it is prepared and stored at temperature at -20°c with the aid of jacketed tank cooled by chilled glycol/water .

4-Buffer:

Buffer is weak acid added to the reactor to maintain the PH around 7.

►Where main reactant is Vinyl Chloride Monomer VCM is stored and feed in liquid status, and it is reacting in the presence of DMW (demineralized water) with about 10 μs conductivity, to avoid killing and oxidizing the initiator.

●In the polyhouse area the reactors are prepared by flushing and coating then it is ready for feeding the batch raw material with the following sequence:

_Coating and charge phase.

1-Coating for reactor internal body

2-N2 blanketing $\Delta P = .1\ barg$

3-Cold DM water charge to the reactor

4-SAP charge (suspending agent primary)

5-SAS charge (Suspending agent secondary)

6-Agitator of the reactor start.

7-RVCM (recovered vinyl chloride monomer) by 15% of total monomer quantity

8-FVCM (fresh monomer) by 85% of total monomer.

9-Hot DMW charge to the reactor.

10-T° c set point and cascade.

11-flushing to the additives charge line.

►Then reaction control phase and all pressure and temperature set points to cascade mode.

●This reaction is Exothermal reaction and the reactor jacket is cooled by cooling water controlled flow to maintain the reaction set point only, avoiding over cooling and killing the reaction ,or less cooling and the reaction runway due to high reaction rates and all monomer will not be uniformly shaped it will be coagulated

●This reaction time is about 3.5 hrs for completing the reaction with conversion of 85%.

●After the reaction proceeded at the end of the reaction the temperature and the pressure is peaking as the reaction rate is peaked also for the termination of the chains.

●The reaction completed and temperature and pressure starts to fail, so short stop to be added .for killing any free radicals that may auto polymerize at any downstream stages.

2-Blowdown Phase:

_ ●After reaction termination finished the reactor is in blowdown mode and this phase for (degassing) or removing the un-reacted monomer (in gas phase)

And for first degassing stage the reactor valve and pumps are controlled by following sequence:

1-Lining up the empty blowdown tank.

2-opening the reactor bottom main on/off valve.

3-slurry is flowing from the reactor by the pressure difference between the reactor and the blowdown vessel which is opened from top to the monomer recovery header to the HP liquid ring compressor.

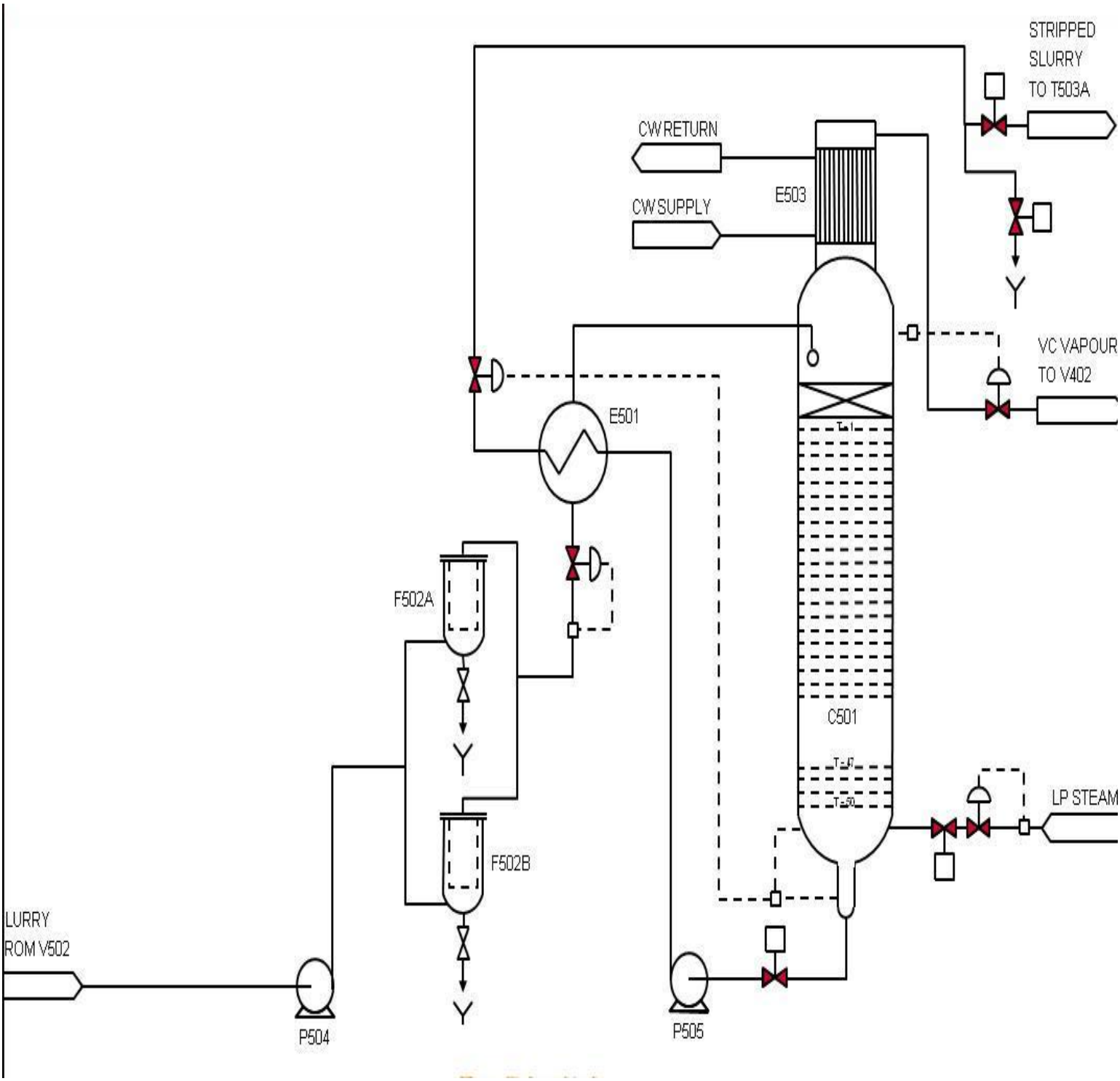
4-when the flow rate of the blow down stage started to decrease and become slow , so the rundown pump will automatically starts.

5-The line from reactor top to recovery header to HP liquid ring compressor will open and also.

6-then at low level the rinse high pressure water will start and then the reactor agitator will stop.

7-finally reactor emptied out and again set to IDLE phase for next batch.

3-Steam Stripping for LP monomer recovery:



►Stripping system explanation:

●The slurry flow is coming from the blowdown system , for next degassing system of the low pressure VCM vapors , to the stripping feed vessel , which acts as continuous stock feed for the stripping column.

Where the stripping column has these phases :

- ► IDLE (shutdown)
- ► Standby
- ►running

To go from shutdown phase to the stand by phase :

1-start flush water with low flow from the feed line to the spiral heat exchanger then from the spiral heat exchanger line up to column top nozzle,

2-continue till the bottom sump of the column starts to build the level then slowly start the bottom steam feeding to column bottom under the last tray.

3-start the column bottom pump to the spiral heat exchanger and line up to the spiral cooler , then to drain line.

4-keep it like this, till the temperature of the column starts to increase , then increase the water flow slowly and in parallel increase the low pressure steam flow.

5-gradually continue till you reached to bottom target temperature @ 113° to 118 ° and top temperature at 100°, then

keep it running like this and ask to field operator to check for any abnormalities.

6-if everything is ok so proceed to the next step of slurry feeding and slurry feed pump running, then close the flush water valve gradually, not to cut the feed to the column which may harm the column stability and may cause steam hammering.

7-then adjust the steam flow , and slurry feed to the column and the split range valve to the column and its recycle to the stripping feed tank.

8- the stripping system to be maintained stable by steam/slurry feeding and the temperature profile along the column.

●AIR BUBBLING FOR THE SLURRY STRIPPING COLUMN

PURPOSE:

As the slurry stripping operation is almost a continuous process, the slurry stripping column would be running for at least 10 to 15 days, nonstop. Hence the possibility of PVC accumulation on the stripping column trays. This accumulation leads to increase in the pressure drop in the column which leads to flooding of the column. Also some of the particles get overheated /burnt changing the color to yellow/ pink/ and black resin particles due to the long heat history. To avoid the above phenomenon, the stripping column is air- bubbled every 10 days to get rid off these overheated particles and thus to sustain good quality of the product.

PREREQUISITES:

Stripping Column air- bubbling is carried out as per schedule once in 10 days, one or two days is permitted to deviate depending on the column operating condition. This activity is planned during a brief shutdown or interruption for more than 3 hrs, based on the assessment of the Plant Manager. The interruption could be due to Grade change-over or dryer shut down or any other major activity planned in any unit of the plant.

PRECAUTIONS:

Before starting air -bubbling activity, ensure stripper column is evacuated, vented to atmosphere by opening the vent valve and filled with water. Two precautions are to be taken to protect the safety of the environment and the equipment.

1. The column and the related equipment to be made free of VCM by proper recovery and evacuation, otherwise VCM will be released during flushing and bubbling.

2. The column top vent valve should be opened to release air during air- bubbling. Otherwise air will pressurize the equipment and the Rupture Disc of the column will be blown-off.
3. Do not stop the feed pumps while flushing
4. Close the XVs,-in the suction and open the XVsat the discharge at the same time to flush the feed line and the interchanger; flush top dome by opening the flush water valve going to top tray & also flush short recycle line.
5. Change Column Bottom level(LICA-30201) set point to zero, to completely empty the column.
6. Keep checking the sample point drain and divert the column discharge stream to drain, once clear water starts coming out from the sample point.
7. 7 Stop flushing to column by closing XV-s once you get clear water from sample point.
8. 8 Stop steam by putting the steam controller FIC 30205 on manual and close it.
9. 9 When the level LIC-30201 reaches zero, stop column bottom pumps and flush it.
10. 10 Close both the column bottom valve & the recycle valve to the column.
11. 11 Put the PIC 30202 on manual & close it. Also close the manual valve after PV302-02 and stop the compressor. If column is down, do not stop the compressor, since it may be required to run the compressor for Waste water stripper
12. 12 Isolate & prepare LP compressor for suction strainer cleaning.

13. 13 Discharge all water from the condensate separator to waste water tank.
14. 14 Stop the separator pump & close manual valve on the discharge line.
15. 15 Notify the board operator that you are going to put the column on VCM evacuation.
16. 16 Line up VCM evacuation by opening isolation valve of evacuation header & ask the board operator to start batch recovery compressor.
17. 17 Continue to pull the VCM until pressure in the column reaches to - 90 to -100 kpag pressure.
18. 18 Ensure that column temperature reaches to 80°C during VCM evacuation with steam open to around 1500 kg/hr.
19. 19 Close the evacuation header and ask the board operator to stop the batch compressor.
20. 20 Open column to atmosphere by opening drain of column filters & drain of P-70304A/B
21. 21 Take FIC-30202 on manual and close it completely.
22. 22 Line up flush water to column inlet & gradually open FV in steps of 10% up to full open, to avoid blowing of R/D on spiral exchanger.

23 Ask Board Operator to close the flush water when column is filled with water and water starts coming out from both column condensate separator pump suction drain lines .

24 Start air bubbling by opening air connected at bottom of the column.

25 Back flush both exchangers thoroughly E-70301 and E-70302 during air bubbling.

26 After one hour of air bubbling start to drain column through drain line of strainers to sewer.

27After draining is over again start flushing the column by opening XV and FV (gradually) until you get clear water at the drain line of the strainer.

28 Once you get clear water, start warming up the column &

start the feed as per the column start up procedure.

4-Compression and liquefaction for monomer recovered vapor:

►from the previous stages of degassing we hape to streams of recovered VCM vapors:

A-High pressure recovered monomer vapors: and this is separated from the batch reactors itself and from the blow down vessels and the streams are collected to one header to the High Pressure liquid ring compressors which are responsible for collecting the vapors of high pressure to the catch pot then to compressor suction.

B-Low pressure recovered monomer which is collected from the stripping feed vessel vent and from the stripping column and also from waste water packed column, to the low pressure compressors catch pot, then to be compressed.

Both compression systems are discharging the compressed vapors at same pressure about 4.5 bar to the next stage of recovered monomer liquefaction system, which consists of series of Shell and tube H.Ex using chilled water and chilled glycol for decreasing the temperature to 10 at the pressure of 4.5 which liquefy the RVCM (recovered monomer) to the storage tank for reusing again in the next batches.

5-Slurry Dewatering and drying systems:

►The slurry trip doesn't stop at the stripping system, but it continues to the next dewatering system as S-PVS is a dry small coarse powder, so we eliminate from the water by three stages:

1-Dewatering Centrifuges

2-Flash dryer

3-Fluid bed dryer

S-PVC Powder

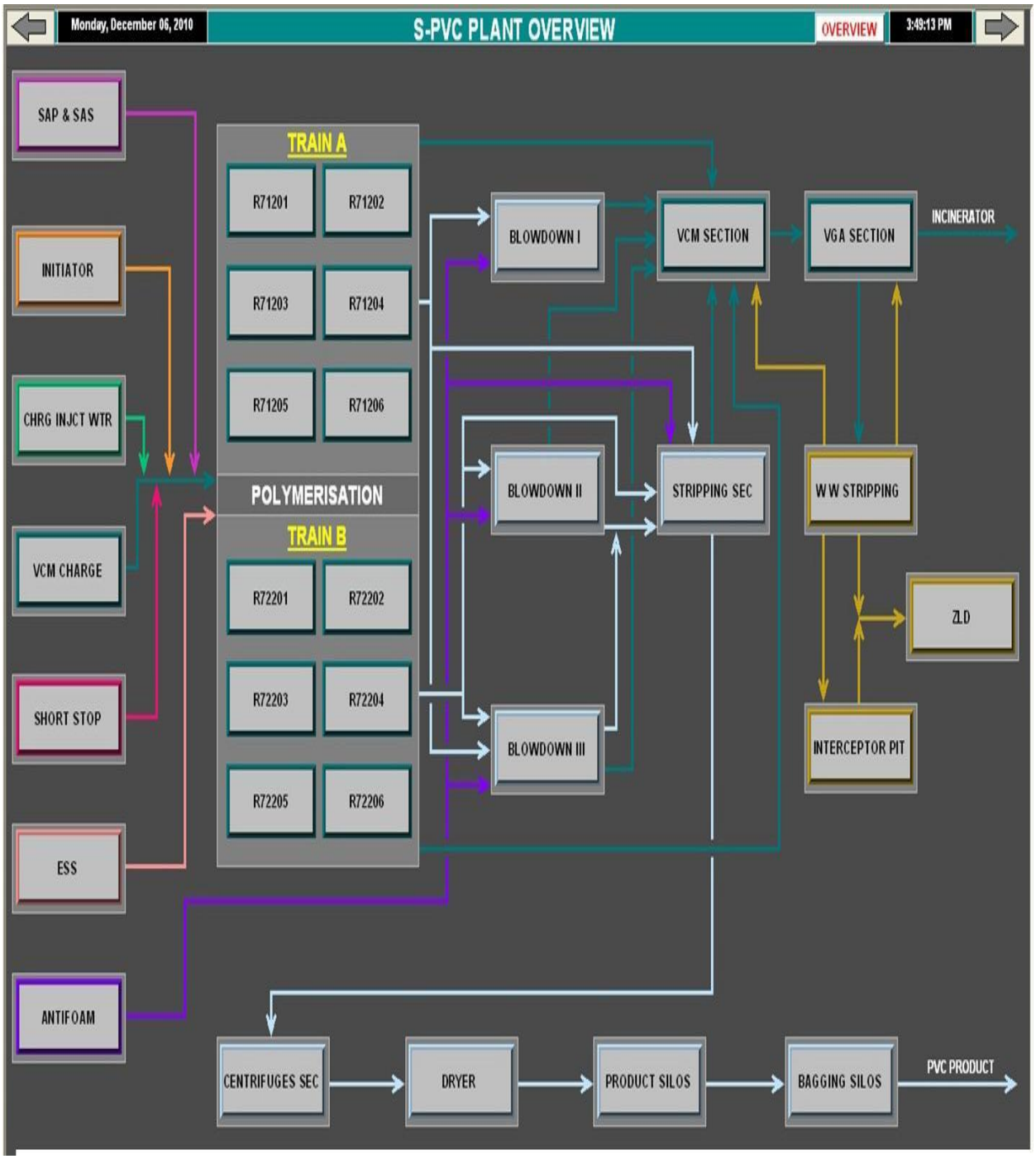
►Dewatering centrifuges : these are some types of mass transfer drying , by the centrifugal effect at which the slurry enters with high water content and it is centrifuged and according to the density difference between the water and the PVC , the water is eliminated partially and cake is pumped out he centrifuge which is operated at definite torque for pre –controlled slurry flow.

►The pumped PVC out of the centrifuge cake is about 32% water content which is conveyed by super heated steam to the flash drying system which is depending on the using of water elimination by flash drying using preheated air by system of series bundles of high pressure and low pressure steam to control and adjust the required temperature for proper moisture content control.

►then from the flash separation the powder is collected in conveying hoppers to the fluid bed dryer m as the inlet moisture content is about 2-3% feed to the dryer and then it leaves about .2 to .3 % by wt moisture content as per standardized

► the fluid bed dryer is operated by the principal of fluidizing the powder collected inside the dryer volume by using preheated air and the air is filtered and preheated and introduced from the fluid bed dryer bottom through ,directed pores mesh ,to transfer the entered slurry from section to another over the barriers inside the dryer till it reaches to the dryer outlet to a rotary valve , which is controlling the flow to the next screening system and also adjust the dryer fluidized bed level.

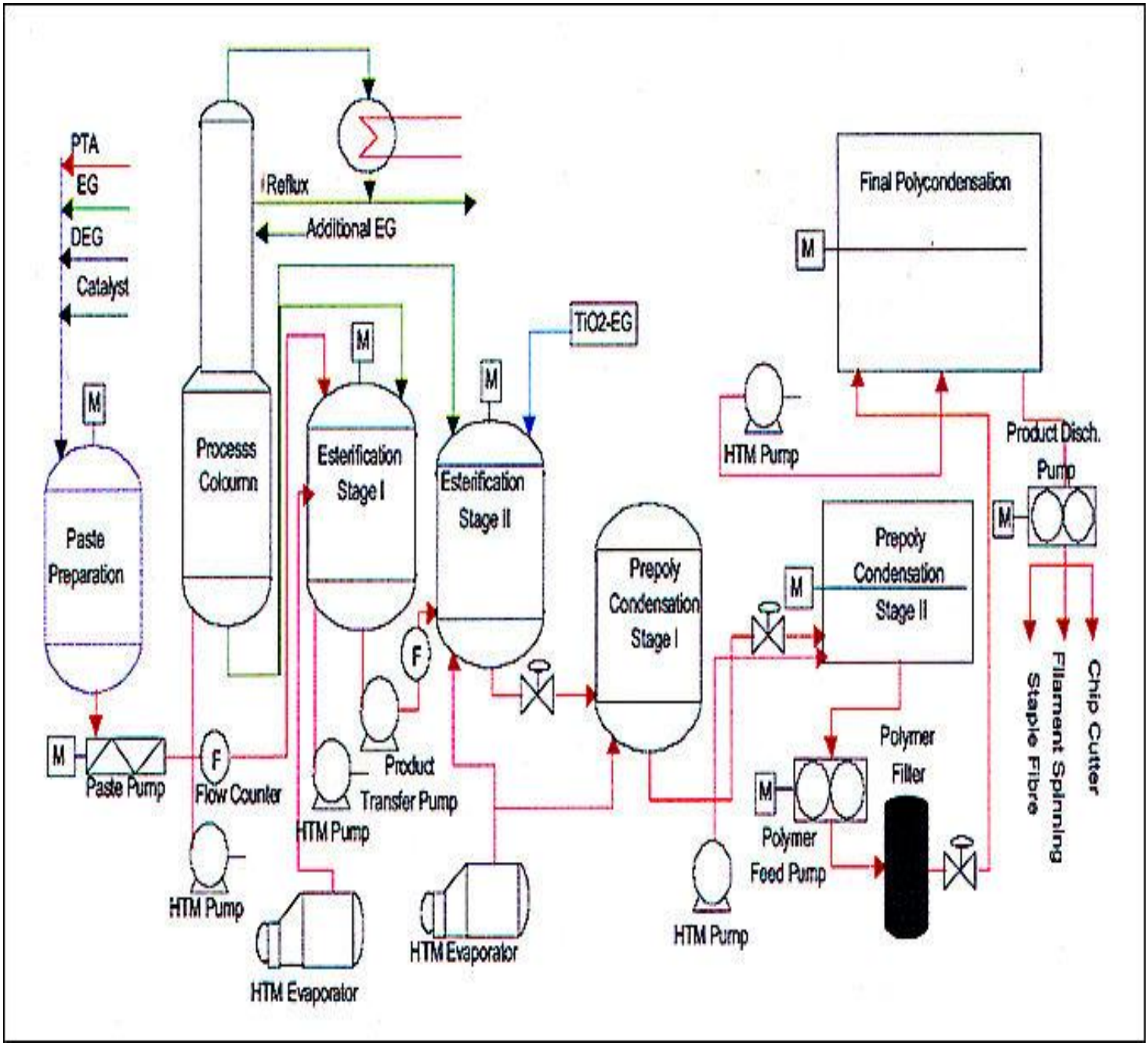
This is the block diagram for the S-PVC plant



►► Continuous Polymerization process

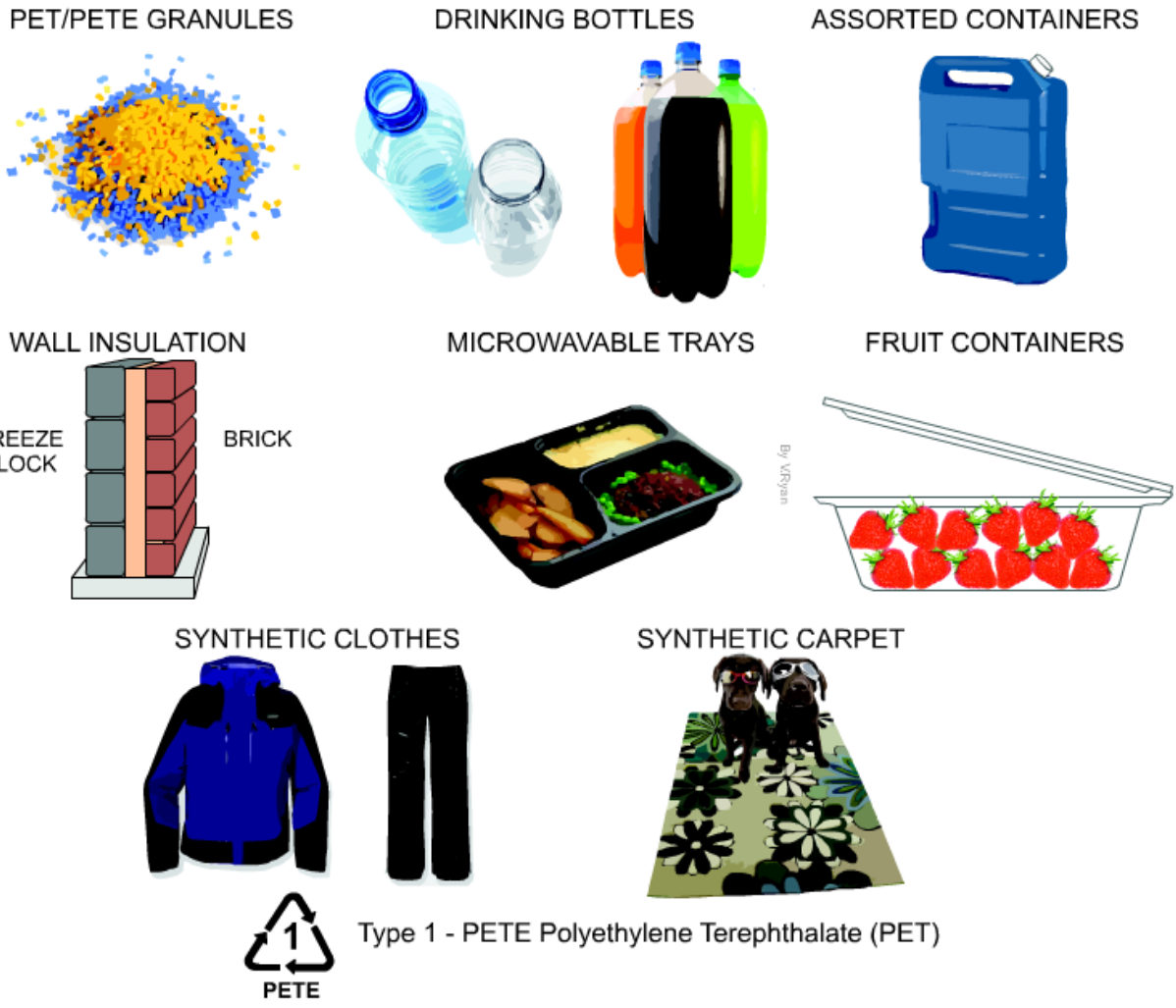
►Polyethylene Terephthalate (polyester)

General process over view



►Product specifications and applications:

PET crystalline chips



●PET grades and specifications:

►The main property that is segregating the different PET grades from each other is the intrinsic viscosity which determine the basic physical properties of the grade like crystalinity degree

Intrinsic viscosity

One of the most important characteristics of PET is referred to as intrinsic viscosity (IV).

The intrinsic viscosity of the material, found by extrapolating to zero concentration of relative viscosity to concentration which is measured in deciliters per gram (dℓ/g). Intrinsic viscosity is dependent upon the length of its polymer chains but has no units due to being extrapolated to zero concentration. The longer the polymer chains the more entanglements between chains and therefore the higher the viscosity. The average chain length of a particular batch of resin can be controlled during polycondensation

The intrinsic viscosity range of PET:

●Fiber grade

0.40–0.70 Textile

0.72–0.98 Technical, tire cord

●Film grade

0.60–0.70 BoPET (biaxially oriented PET film)

0.70–1.00 Sheet grade for thermoforming

●Bottle grade

0.70–0.78 Water bottles (flat)

0.78–0.85 Carbonated soft drink grade

●Monofilament, engineering plastic

1.00–2.00

►Polyethylene Terephthalate polymer properties:

PET in its natural state is a colorless, semi-crystalline resin. Based on how it is processed, PET can be semi-rigid to rigid, and it is very lightweight. It makes a good gas and fair moisture barrier, as well as a good barrier to alcohol (requires additional "barrier" treatment) and solvents. It is strong and impact-resistant. PET becomes white when exposed to chloroform and also certain other chemicals such as toluene.

About 60% crystallization is the upper limit for commercial products, with the exception of polyester fibers. Clear products can be produced by rapidly cooling molten polymer below T_g glass transition temperature to form an amorphous solid. Like glass, amorphous PET forms when its molecules are not given enough time to arrange themselves in an orderly, crystalline fashion as the melt is cooled. At room temperature the molecules are frozen in place, but, if enough heat energy is put back into them by heating above T_g, they begin to move again, allowing crystals to nucleate and grow. This procedure is known as solid-state crystallization.

When allowed to cool slowly, the molten polymer forms a more crystalline material. This material has spherulites containing many small crystallites when crystallized from an amorphous solid, rather than forming one large single crystal. Light tends to scatter as it crosses the boundaries between crystallites and the amorphous regions between them. This scattering means that

crystalline PET is opaque and white in most cases. Fiber drawing is among the few industrial processes that produce a nearly single-crystal product.

PET Process description:

►This process has different stages from raw material feeding to final production:

1-Paste preparation and (raw materials mixing)

2-Esterification Process.

3-Prepolymerization & condensation Polymerization process.

4-Cutting and conveying the amorphous intermediate.

5-SSP or (Solid State Polymerization).

All stages are continuous stages and dependent of each other only SSP (Solid State polymerization unit) has its own feeding stock silos.

And we will explain the process starting from:

1- Paste preparation

●PTA and MEG along with catalyst solution are mixed in Paste Preparation Vessel for making PTA Paste. The Glycol/ Catalyst is fed accurately via a flow-mole-ratio control station into the PTA paste preparation vessel. At the same time PTA powder is metered via the PTA discharging device.

The PTA paste is continuously fed to the esterification reactor 1 via PTA paste pumps.

●The PTA being fed into the PTA silo

●During discharging the PTA powder into the weighing system Nitrogen is blown 2 seconds before the butterfly valve opens and 4 seconds after the valve is opened.

●The PTA powder is charged continuously with the aid of PTA metering system at a rate commensurate with the fixed throughput to the PTA paste mixing vessel .

●The level in the PTA paste mixing vessel is controlled by the PTA feed rate of the PTA weighing unit. THE feed in components are homogeneously mixed with the aid of the built in paste mixer of special design .

●The amount of glycol corresponding with the specified mole reaction is automatically controlled and maintained constant from the control panel.

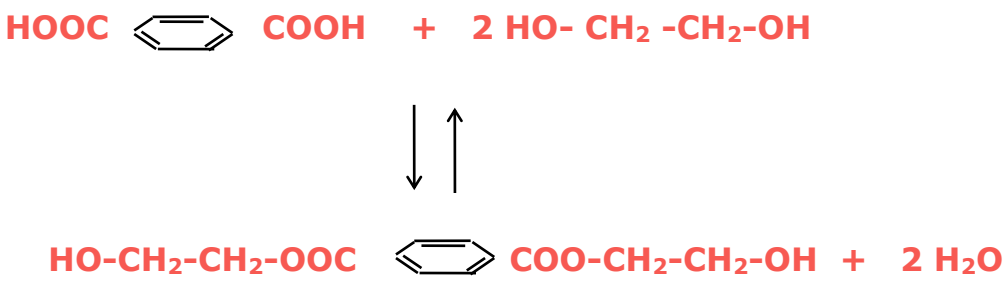
●The PTA paste is discharged cont. from the PTA paste mixing vessel by applying the PTA paste pumps and passed to the esterification section .When the paste is not fed in to the esterification stage the material is refluxed to the PTA paste mixing vessel .

●Normally both pumps are in operation Unless being exposed to sharing forces the paste trends to solidify any accidentally occurring clogging can be eliminated with the aid of fresh glycol

without having to interrupt the process for a prolonged period of time.

2-Esterification stage:

In previous module preparation of PTA-MEG slurry and transfer of slurry to EST –I is explained. In this module Reactor operation for preparation of Oligomer, operation of Separation column for separating EG & Water and operation of Stripping column for stripping out organics from effluent water is explained.

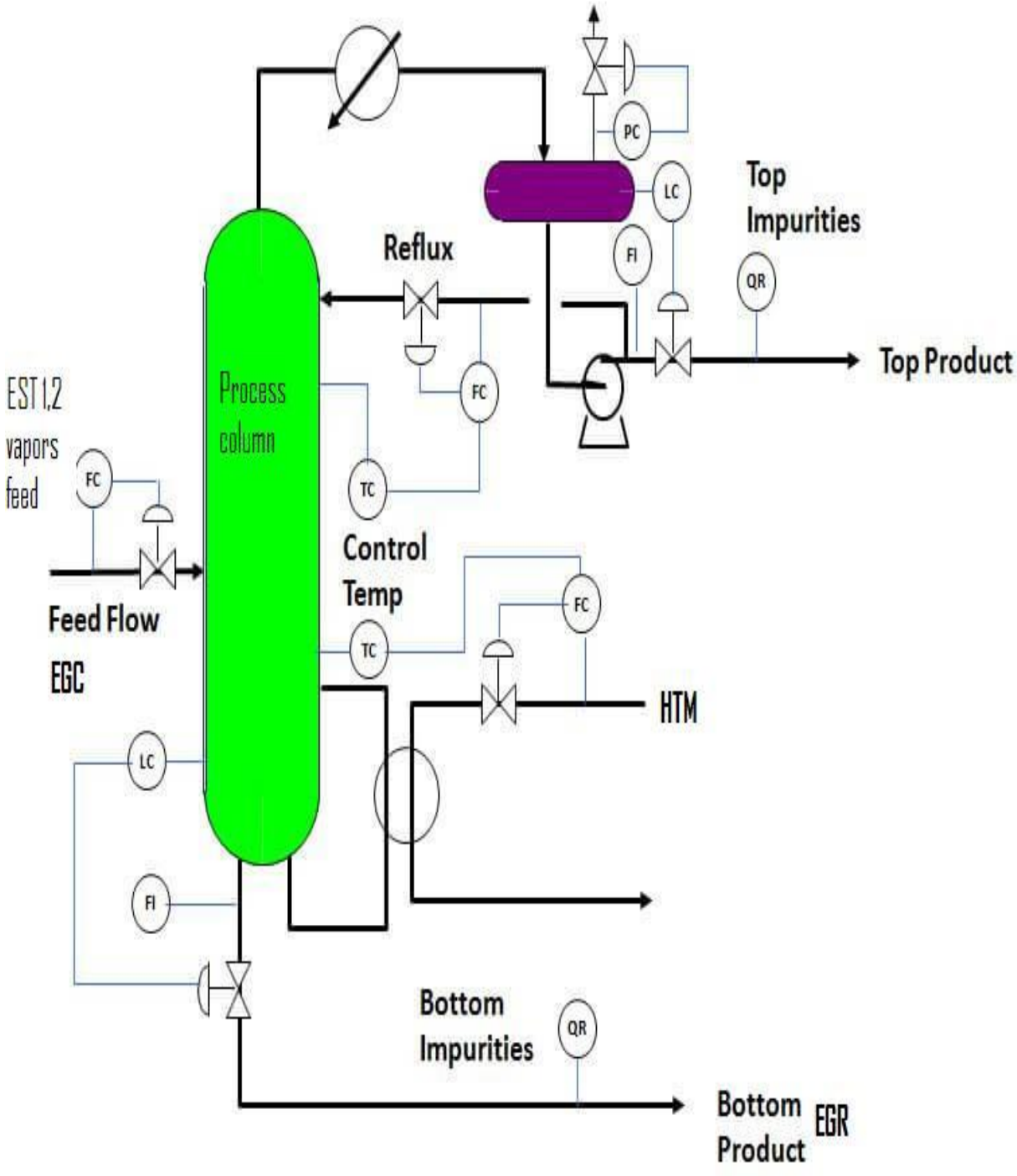


In this section PTA and glycol are esterified under graduated pressure and with rising temperature to terephthalic diglycol ester while water is being split off. Together with the water vapor a part of the free glycol leaves the section and these two components are separated by way of distillation The glycol is refluxed in to the esterification reactors I&II The esterification takes place in two series connected reactors due to the graduation in pressure from the esterification stage I to EST II.

►PROCESS COLUMN

The water/glycol vapors leaving the esterification stages are conducted via the vapor manifold to the bottom of the process column 1401 in order to separate any eventually any sublimates (PTA , Oligomers , DGT) The water/glycol leave the sump of the process column where the vapors are fractionated with the aid of trays to their components that means water and glycol . The water containing a slight portion of glycol is passed over the head to the total condenser system ,From the condensate of the condenser a partial stream flows back as a reflux to the column while the remainder is discharged into waste water system. In order to attain a satisfactory refraction a heating coil is installed in the bottom of a distillation column. The bottom product of a d/c is divided. The main stream passes to the esterification stage I. A partial stream is found to esterification stage II .

A spray nozzle is provided below the vapor inlet of the column to prevent a remainder of oligomer on the trays the minimum temperature of the sump should be 190degC. The level in glycol column is maintained constant in the case of a rise of a glycol level above the normal level the excess glycol is discharged into the vessel.



Process Column

►Process column

Vapors of the esterification stages and glycol vapour evaporated in the process column sump are raising in the column to the top. From the top of the process column condensed process column sump. Mass transfer between vapors and the liquid causes an accumulation of low boilers as mainly water at the top of the column. The glycol concentration is increasing towards the process column sump. Concentrated glycol will be removed from the sump.

•Pressure

The condenser on the column head is under atmospheric pressure. The pressure in the column sump results from the pressure drop of the rising vapours through the column internals.

•Sump-temperature

For the evaporation of the sump product in the column a heating coil heated with liquid secondary HTM is installed in the sump. The flow rate of secondary HTM through the heating coil is controlled by the temperature in the column sump. The temperature in the secondary HTM loop is kept constant by primary HTM injection.

•Column temperature

The temperature profile in the column corresponds to the degree of separation of the components. The desire separation can be regulated by the column reflux rate.

•Glycol flow

The bottom discharge pump transfers glycol from the column sump back t the esterification stages. The excess glycol of the process is pumped to the glycol collecting vessel. The level in the column sump is kept constant by a control valve in the glycol line to the glycol collecting vessel.

•SEG collecting vessel

In the SEG collecting vessel the excess glycol from the prepolycondensation vacuum system is collected. From there it is fed by gravity into the process column for purification.

3-►Prepolycondensation stage:

1. Equipment of the Prepolycondensation

- Prepolycondensation reactor
- Agitator of Prepolycondensation reactor
- HTM evaporator
- HTM circulation pump

2. What takes place in the Prepolycondensation?

The polycondensation reaction which has already started in the esterification under overpressure continues under vacuum in the Prepolycondensation reactor. Low-molecular polyester is formed out of the esterification product by splitting off glycol.

Furthermore the esterification reaction continues in the prepolycondensation reactor and water is produced as a by-product. The generated split glycol and the water are removed by the vacuum system of the prepolycondensation (PP).

3. How does the prepolycondensation work?

Feed

From esterification stage 2 the esterification product is continuously fed into the prepolycondensation reactor. The flow rate of the product from esterification 2 reactor is controlled by the level of prepolycondensation reactor using a control valve at the inlet of prepolycondensation reactor.

Prepolycondensation reactor

The prepolycondensation reactor is a vertical reactor with different sections. The upper sections are designed as ring channels. Free internal overflows let the product from one section into the next lower section and cause a constant level on the ring channels. Therefore the residence time of the product on the ring channels changes with throughput.

The vapor space of the inlet ring channel is separated from the lower sections. Vapors of the inlet ring channel are sucked off via the common vapor space of the three lower sections passing a turn round baffle plate. Prepolycondensation vapors reach the vacuum system of prepolycondensation via vapor line.

The ring channels are jacket heated by vapor HTM. The upper ring channels at the product inlets are equipped with a heating coil. In these channels a large surface of the heating coils ensures the vaporization of glycol and water during the reaction.

The agitator of the prepolycondensation reactor to renew surface of prepolycondensation reaction and removal of vapors stirs the section in the bottom of the reactor.

The degree of polycondensation is mainly controlled by pressure, but also temperature, residence time and quality of the feed have an influence.

Temperature

In the prepolycondensation reactor a constant temperature must be maintained to ensure an even prepolycondensation product. Therefore, the heating coils in the upper ring channel of the prepolycondensation reactor are heated with liquid HTM.

HTM vapor, produced by the HTM evaporator, heats the heating jacket and the ring channels jackets of prepolycondensation reactor. The HTM evaporator also provides HTM vapor to the esterification stage 2 jacket.

The vapor line of prepolycondensation reactor is also HTM vapor heated but the vapor supplied from the HTM evaporator of the glycol vapor jet.

The HTM circulation pump circulates the liquid secondary HTM through the heating coils of prepolycondensation reactor. HTM from the primary circuit is injected into this circuit to control

the temperature of the secondary HTM circuit. An even product temperature in the upper ring channel is ensured by using a temperature controller with control valve at the liquid HTM outlet of the coil in the ring channel.

The stand-by HTM circulation pump of esterification stage 2 is common stand-by pump for esterification stage 2 and prepolycondensation reactor.

Pressure

The prepolycondensation process is carried out under vacuum. The vacuum is generated and controlled in the first condenser of the glycol vapour jet. The vacuum line connects the glycol vapour jet with the prepolycondensation reactor via the vacuum system of prepolycondensation.

The pressure in the upper ring channel is higher than in the lower ring channel and in the bottom part of the prepolycondensation reactor, because the vapours from the upper ring channel have to pass the turnaround baffle plate before they are entering into the vapour line to the vacuum system.

Product flow

The product flow between prepolycondensation reactor and disc ring reactor adjusted by the prepolymer feed to the disc

ring reactor is controlled by the level of the disc ring reactor and the speed of the product discharge pump which corresponds to the throughput oh the plant.

►Polymerization stage at Disc ring reactor

1. Equipment parts of disc ring reactor

- Disc ring reactor
- HTM evaporator

2.What takes place in the disc ring reactor?

The degree of polycondensation of the incoming low-viscosity prepolymer is increased in the disc by lowering the pressure and rising the polymer temperature. In the disc ring reactor the polymer chains reach the desired length. The final high-viscosity polymer is formed by splitting off glycol. The split glycol formed during the process is removed by the vacuum system of the polycondensation.

3. How does the disc ring reactor works?

Feed

From prepolycondensation stage the prepolymer is fed via the prepolymer feed pump into the disc ring reactor. The prepolymer flow to the disc ring reactor is controlled by the

average level of the disc ring reactor and the speed of the product discharge pumps, which corresponds to the throughput of the plant.

•Disc ring reactor

The disc ring reactor is a horizontal, cylindrical vessel with several stirred chambers. The centre line of the of the agitator shaft is positioned below the horizontal centre line of the disc ring reactor to ease the process vapor discharge at the top of the reactor. The agitator consists of several disc ring located along the agitator shaft. Because of these disc rings the reactor type is called "disc ring reactor "(DRR). The disc ring reactor is connected to a vacuum system, which generates the vacuum in the stage.

The polymer is lifted up from the reactor sump by the rotation of the disc rings, forms a thin film on the disc rings and flows back into the reactor sump. Due to the increased surface of the product, the glycol split off in the polycondensation process can easily evaporate. The split glycol is removed from the stage and finally condensed in the vacuum system of the polycondensation.

•Temperature

HTM vapor, produced by the HTM evaporator, heats the heating jacket of the complete reactor.

The vapor line of the disc ring reactor is heated with HTM vapor generated by the HTM evaporator of the glycol vapor jet.

•Pressure

The polycondensation process takes place under vacuum. The vacuum of the disc ring reactor is generated and controlled in the glycol vapor jet system. The glycol vapor jet is connected with the disc ring reactor via the vacuum system of the polycondensation by the vapor line.

•Polymer viscosity

The viscosity of the polymer is basically controlled by the vacuum in the disc ring reactor. The prerequisites of an automatic via control are constant residence time, constant feed quality, agitator speed and temperature in the disc ring reactor.

The viscosity meter in the product discharge line of the disc ring reactor measures the viscosity of the polymer and controls the vacuum of the disc ring reactor. When the viscosity of the polymer varies, the position of the viscosity meter causes a delayed reaction of the vacuum controller of the reactor, due to the residence time of the polymer in the disc ring reactor and in the product discharge line.

The agitator current consumption indicates a change of the polymer viscosity in the disc ring reactor earlier than the viscosity meter in the product discharge line. For that reason the variation of current consumption of the agitator of the disc

ring reactor is also used to control the vacuum in the disc ring reactor.

The variation of current consumption is cascade controlled by the polymer viscosity measured by the viscosity meter in the product discharge line.

•Level control

The speed of the product discharge pumps corresponding to the throughput of the plant controls the speed of the polycondensation feed pump to keep the level in the disc ring reactor constant. The average level of the disc ring reactor, taken from the values given by the level transmitters at the inlet and outlet of the disc ring reactor, is used to correct the speed of the pre-polymer feed pump if the actual average level in the disc ring reactor differs from the set point.

Depending on the polymer viscosity, there is always a considerable polymer quantity on the disc rings. Therefore, the displayed level in the disc ring reactor does not correspond to the polymer quantity actually present.

The amount of polymer lifted up from the reactor sump by the disc rings becomes more with increased polymer viscosity. For that reason the displayed level at the entrance of the disc ring reactor is higher than the displayed level at the outlet of the reactor.

►Pelletizing system

1. Equipment of the pelletizing system

- ❖ Pelletizing system
- ❖ Over length separator
- ❖ Cutter hoist

2. What takes place in the pelletizing system?

The polymer melts exits polymer line to atmosphere at the die head of the pelletizing system in form of strands. Afterwards the polymer strands are quenched and carried by demineralized water of the cutting head for granulation.

The so produced solid polymer chips are carried by demineralized water flow to a chip dryer and the water is separated. Chips with excessive length are separated in the over length separator. The chip of correct size is conveyed to the intermediate chip silo of the discharge system.

Pelletizing system

The pelletizing system consists of following components:

- ❖ Die head
- ❖ Underwater granulator
- ❖ Granulate dryer

The polymer melt is discharged via the holes of a die head to atmosphere. The polymer exits the die head in the shape of a strand.

Afterwards the polymer strands are quenched with demineralized water and carried by demineralized water to the cutting head of the underwater granulator.

The underwater granulator consists of the following components:

- Strand guide head
- Cutting head
- Permanent oversize separator
- After cooling line

In strand guide section the polymer strands are solidified and cooled by demineralized water, which is sprayed on the strands with several spray nozzles. The demineralized water is supplied by demineralized water circulation system. With the demineralized water flow the strands are conveyed to the pelletizer.

The strands are fed to the draw-in section of the pelletizer and enter the cutting head. The cutting head of the pelletizer consists of a rotating and a fixed blade and cuts the strands into chips.

A part of the conveying water is separated already in the pelletizer and fed back to demineralized water circulation system by gravity flow.

The chips are then conveyed into the chip dryer via the permanent oversize separator of the pelletizer and after

cooling line of pelletizer by demineralized water. In the permanent oversize separator a pre-separation of not properly cut strands take place. In the after cooling line the chips are cooled and solidified further with demineralized water.

The wet chips are continuously dried in the chip dryer. The chips are dried by an air stream generated by the chip dryer fan. While passing several conveying channels inside the dryer the water is mechanically separated from the chips before the chips leave the dryer and drop onto the overlength separator. The wet air is exhausted to atmosphere.

The remaining heat of the chips provides a further reduction in the residual moisture.

The cutter hoist is used for lifting the cutter head during maintenance.

Chips size

The length of the produced cylindrical chip is determined by the cutter speed. The size of the chips is adjustable up to a certain extent by the speed of the draw in the unit of the underwater granulator. To maintain an even chip size at different throughputs via the die head, the draw in speed has to be controlled proportional to the throughput of the die head. Due to the laminar polymer flow in the product line the pressure in the polymer line is directly proportional to the actual polymer flow rate in this line. Therefore the measured

polymer pressure in the product line and the polymer flow rate are used for cascade control of the draw in speed.

Over length separator

From the dryer the chips drop onto the moving perforated plate of the over length separator. The chips with a proper size are passing through the holes, while the chips with over length leave the over length separator via a separate exit where they are collected. The on-spec chips fall into a chip pipe and subsequently in the intermediate chip silo of the discharge system.

Demin. Water circulation system

1. **Equipment of the demin. water circulation system**
   - ❖ Demin. Water system
   - ❖ Demin. Water pumps
   - ❖ Demin. Water filters (with demin. water vessel)

2. **What takes place in the demin. water circulation system?**

In the demin. water circulation system the demineralized water used for cooling, solidification and transport of the polymer melt and the produced chips in the pelletizing systems is circulated, filtered and cooled.

Demineralized water is used in this system to avoid minerals sticking on the surface of the chips, while the water is

evaporated during solidification of the polymer melt, as minerals will cause negative effects in further processing steps.

3. How does the demin. water circulation system works?

Circulation

The demineralized water is discharged from the demin. water vessel and circulated via the demin. water cooler, the pelletizing system and the demineralized water pump.

To obtain constant demineralized water inlet pressure at the pelletizing system an automatic pressure control valve is located in a bypass line to the demineralized water vessel.

The returned demineralized water from the chip dryer of the pelletizing system flows by gravity flow via the demin. water vessel.

Feed

Demineralized water which is evaporated in the pelletizing systems has to be refilled to the demin. water vessel. This is done by means of a float type feed valve. In case of a level alarm low, the demin. water vessel has to be refilled manually.

Filtration

Solids (e.g. pellet abrasion) in the demineralized water circulation will cause operation problems systems can block the spray nozzles of the pelletizing system and cause shutdown of the pelletizing system. Therefore the solids are removed from the demineralized water circulation. A band filter removes the solids from the water. The filter is operating fully automatically.

► Amorphous storage

After polymer is cut into small pellets it is dried and conveyed with air to the amorphous storage silo at which it is fed to the next SSP (solid state polymerization)

►SSP(solid state polymerization):

It is the stage at which the crystallinity and the I.V is improved to the commercial required limits.

It consists of:

- Surge feed silo
- Precrystallizer
- Crystallization stage
- SSP Reactor (plug flow Reactor)
- Nitrogen purification unit
- Pellets cooler
- Conveying system to the storage and bagging silos.

Chapter 4

Process Control

General basic definitions:

►Process control :

is the automatic control of an output variable by sensing the amplitude of the output parameter from the process and comparing it to the desired or set level and feeding an error signal back to control an input variable.

►Feedback loop :

is the signal path from the output back to the input to correct for any variation between the output level from the set level. In other words, the output of a process is being continually monitored, the error between the set point and the output parameter is determined, and a correction signal is then sent back to one of the process inputs to correct for changes in the measured output parameter.

►Controlled or measured variable:

is the monitored output variable from a process. The value of the monitored output parameter is normally held within tight given limits.

►Manipulated variable :

is the input variable or parameter to a process that is varied by a control signal from the processor to an actuator. By changing the input variable the value of the measured variable can be controlled.

►Set point:

is the desired value of the output parameter or variable being monitored by a sensor. Any deviation from this value will generate an error signal.

►Instrument :

is the name of any of the various device types for indicating or measuring physical quantities or conditions, performance, position, direction, and the like.

►Sensors:

Are devices that can detect physical variables, such as temperature, light intensity, or motion, and have the ability to give a measurable output that varies in relation to the amplitude of the physical variable. The human body has sensors in the fingers that can detect surface roughness, temperature, and force. A thermometer is a good example of a line-of-sight sensor, in that it will give an accurate visual indication of temperature. In other sensors such as a diaphragm pressure sensor, a strain transducer may be required to convert the deformation of the diaphragm into an electrical or pneumatic signal before it can be measured.

►Transducers :

are devices that can change one form of energy to another, e.g.,a resistance thermometer converts temperature into electrical resistance, or a thermocouple converts temperature into voltage. Both of these devices give an output that is proportional to the temperature. Many transducers are grouped under the heading of sensors.

►Converters:

are devices that are used to change the format of a signal without changing the energy form, i.e., a change from a voltage to a current signal.

►Actuators :

are devices that are used to control an input variable in response to a signal from a controller. A typical actuator will be a flow-control valve that can control the rate of flow of a fluid in proportion to the amplitude of an electrical signal from the controller. Other types of actuators are

magnetic relays that turn electrical power on and off. Examples are actuators that control power to the fans and compressor in an air-conditioning system in response to signals from the room temperature sensors.

►Controllers:

are devices that monitor signals from transducers and take the necessary action to keep the process within specified limits according to a pre-defined program by activating and controlling the necessary actuators.

►Programmable logic controllers(PLC) :

are used in process-control applications, and are microprocessor-based systems. Small systems have the ability to monitor several variables and control several actuators, with the capability of being expanded to monitor 60 or 70 variables and control a corresponding number of actuators, as may be required in a petrochemical refinery.

PLCs, which have the ability to use analog or digital input information and output analog or digital control signals, can communicate globally with other controllers, are easily programmed on line or off line, and supply an unprecedented amount of data and information to the operator. Ladder networks are normally used to program the controllers.

►DCS is Distributed control system and its explanation is a type of control system consists of dividing process controls, each is managed by its own controller with the whole system connected to form a single entity usually by means of communication buses &it is applied for manufacturing dynamic system in which the controller elements aren't central in location.
Like brain control , but controller elements are distributed throughout all the plant with its subsystem component, Where all the entire system of controllers are is connected with net works for communicating and monitoring

- DCS is dealing with large number of Inputs and outputs (I/O) cards with less cost, where DCS system is a group of individual smart controllers having the connection with the field devices doing their specified operation duty inter connected.

►Transmitters

are devices used to amplify and format signals so that they are suit-able for transmission over long distances with zero or minimal loss of information. The transmitted signal can be in one of the several formats, i.e., pneumatic, digital, analog voltage, analog current, or as a radio frequency (RF) modulated signal. Digital transmission is preferred in newer systems because the controller is a digital system, and as analog signals can be accurately digitized, dig-ital signals can be transmitted without loss of information. The controller compares the amplitude of the signal from the sensor to a predetermined set point.

Types of Process variables to be controlled:

1- **Pressure measurement:**

is the force exerted by gases and liquids due to their weight, such as the pressure of the atmosphere on the surface of the earth and the pressure containerized liquids exert on the bottom and walls of a container. Pressure units are a measure of the force acting over a specified area. It is most commonly expressed in pounds per square inch (psi), sometimes pounds per square foot (psf) in English units, or pascals (Pa or kPa) in metric units.

-

Measuring Instruments:

►Manometers are good examples of pressure measuring instruments, though they are not as common as they used to be because of the development of new, smaller, more rugged, and easier to use pressure sensors .U–tube manometers consist of U-shaped glass tubes partially filled with a liquid. When there are equal pressures on both sides, the liquid levels will correspond to the zero point on a scale as shown in Fig. 5.5a. The scale is graduated in pressure units. When a pressure is applied to one side of the U-tube that is higher than on the other side .

-

►Diaphragms, capsules, and bellows: Gauges are a major group of pressure sensors that measure pressure with respect to atmospheric pressure. Gauge sensors are usually devices that change their shape when pressure is applied. These devices include diaphragms, capsules, bellows, and Bourdon tubes. A diaphragm consists of a thin layer or film of a material supported on a rigid frame. Pressure can be applied to one side of the film for gauge sensing or pressures can be applied to both sides of the film for differential or absolute pressure sensing. A wide range of materials can be used for the sensing film,

from rubber to plastic for low-pressure devices, silicon for medium pressures, to stainless steel for high pressures. When pressure is applied to the diaphragm, the film distorts or becomes slightly spherical. This movement can be sensed using a strain gauge, piezoelectric, or changes in capacitance techniques (older techniques included magnetic and carbon pile devices). The deformation in the above sensing devices uses transducers to give electrical signals. Of all these devices the micromachined silicon diaphragm is the most commonly used industrial pressure sensor for the generation of electrical signals.

► Vacuum instruments : are used to measure pressures less than atmospheric pres-sure. The Bourdon tube, diaphragms, and bellows can be used as vacuum gauges, but measure negative pressures with respect to atmospheric pressure. The silicon absolute pressure gauge has a built-in low-pressure reference, so it is calibrated to measure absolute pressures. Conventional devices can be used down to 20 torr (5 kPa). The range can be extended down to about 1 torr with special sensing devices.

2- **Level measurement:**

Pressure is often used as an indirect method of measuring liquid levels. Pressure increases as the depth increases in a fluid. The pressure is given by $\Delta p = \gamma \Delta h$

Δp=change in pressure , γ=specific weight , Δh=depth

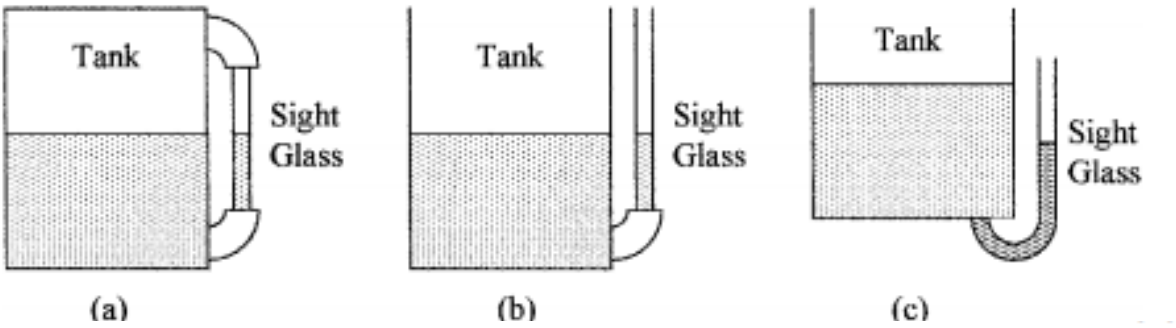
►Level Sensing Devices:

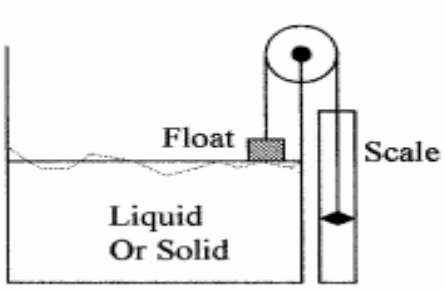
There are two categories of level sensing devices. They are direct sensing, in which case the actual level is monitored, and indirect sensing where a property of the liquid such as pressure is sensed to determine the liquid level.

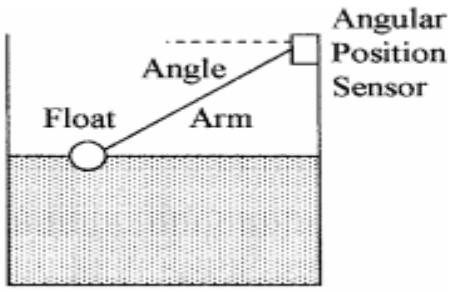
Direct level sensing : Sight glass(open end/differential) or gauge is the simplest method for direct visual reading. The liquid level can

then be observed directly in the sight glass.

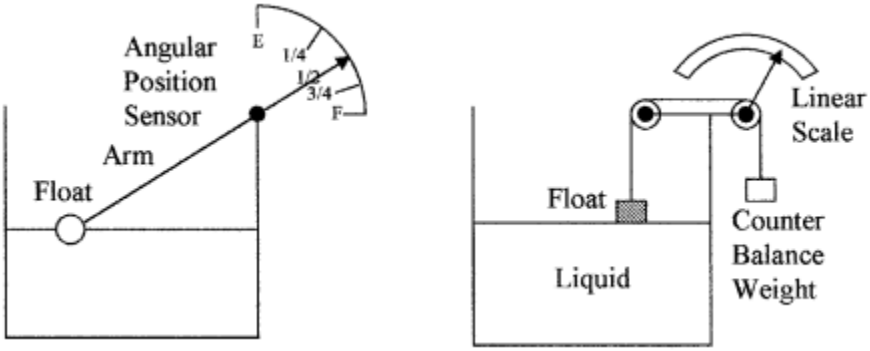
Floats (angular arm or pulley) :types of simple float sensors. The float material is less dense than the density of the liquid and floats up and down on top of the material being measured. float with a pulley is used; this method can be used with either liquids or free flowing solids. With free flowing solids, agitation is sometimes used to level the solids. An advantage of the float sensor is that it is almost independent of the density of the liquid or solid being monitored.







►A displacer: with force sensing is shown in Fig. 6.5a. This device uses the change in the buoyant force on an object to measure the changes in liquid level. The displacers must have a higher specific weight than that of the liquid level being measured and have to be calibrated for the specific weight of the liquid A force or strain gauge measures the excess weight of the displacer. There is only a small movement in this type of sensor compared to a float sensor.



3-Flow measurement:

►**Velocity**: is a measure of speed and direction of an object. When related to fluids it is the rate of flow of fluid particles in a pipe. The speed of particles in a fluid flow varies across the flow, i.e., where the fluid is in contact with the constraining walls (the boundary layer) the velocity of the liquid particles is virtually zero; in the center of the flow the liquid particles will have the maximum velocity. Thus, the average rate of flow is used in flow calculations. The units of flow are normally feet per second (fps),

feet per minute (fpm), meters per second (mps), and so on. Previously, the pressures associated with fluid flow were defined as static, impact, or dynamic. Laminar flow of a liquid occurs when its average velocity is comparatively low and the fluid particles tend to move smoothly in layers,

The velocity of the particles across the liquid takes a parabolic shape. Turbulent flow occurs when the flow velocity is high and the particles no longer flow smoothly in layers and turbulence or a rolling effect occurs. Note also the flattening of the velocity profile.

►**Viscosity**: is a property of a gas or liquid that is a measure of its resistance to motion or flow. A viscous liquid such as syrup has a much higher viscosity than water and water has a higher viscosity than air. Syrup, because of its high viscosity, flows very slowly and it is very hard to move an object through it. Viscosity

(dynamic) can be measured in poise or centipoise, whereas kinematic viscosity (without force) is measured in stokes or centistokes. Dynamic or absolute viscosity is used in the Reynolds and flow equations. Typically the viscosity of a liquid decreases as temperature increases.

The Reynolds number R is a derived relationship combining the density and viscosity of a liquid with its velocity of flow and the cross-sectional dimensions.

►**The Bernoulli equation :** is an equation for flow based on the law of conservation of energy, which states that the total energy of a fluid or gas at any one point in a flow is equal to the total energy at all other points in the flow.

Energy factors Most flow equations are based on the law of energy conservation and relate the average fluid or gas velocity, pressure, and the height of fluid above a given reference point. This relationship is given by the Bernoulli equation. The equation can be modified to take into account energy losses due to friction and increase in energy as supplied by pumps.

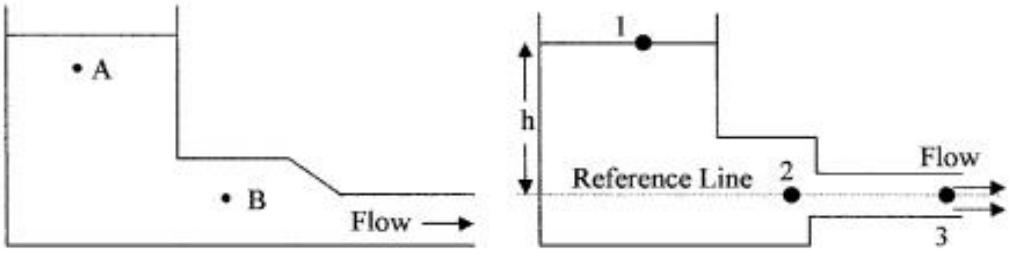
Energy losses in flowing fluids are caused by friction between the fluid and the containment walls and by fluid impacting an object. In most cases these losses should be taken into account. Whilst these equations apply to both liquids and gases, they are more complicated in gases because of the fact that gases are compressible.

Flow rate is the volume of fluid passing a given point in a given amount of time and is typically measured in gallons per minute (gpm), cubic feet per minute (cfm), liter per minute, and so on. gives the flow rate con-version factors

The Bernoulli equation gives the relation between pressure, fluid velocity, and elevation in a flow system. The equation is accredited to Bernoulli (1738). When applied to Fig. 7.3*a* the following is obtained-

$$\frac{P_A}{\gamma_A}+\frac{V_A^{\,2}}{2g}+Z_A=\frac{P_B}{\gamma_B}+\frac{V_B^{\,2}}{2g}+Z_B$$

where P_A and P_B = absolute static pressures at points A and B, respectively
γ_A and γ_B = specific weights
V_A and V_B = average fluid velocities
g = acc of gravity
Z_A and Z_B = elevations above a given reference level, i.e., $Z_A - Z_B$ is the head of fluid.



►Flow Measurement Instruments:

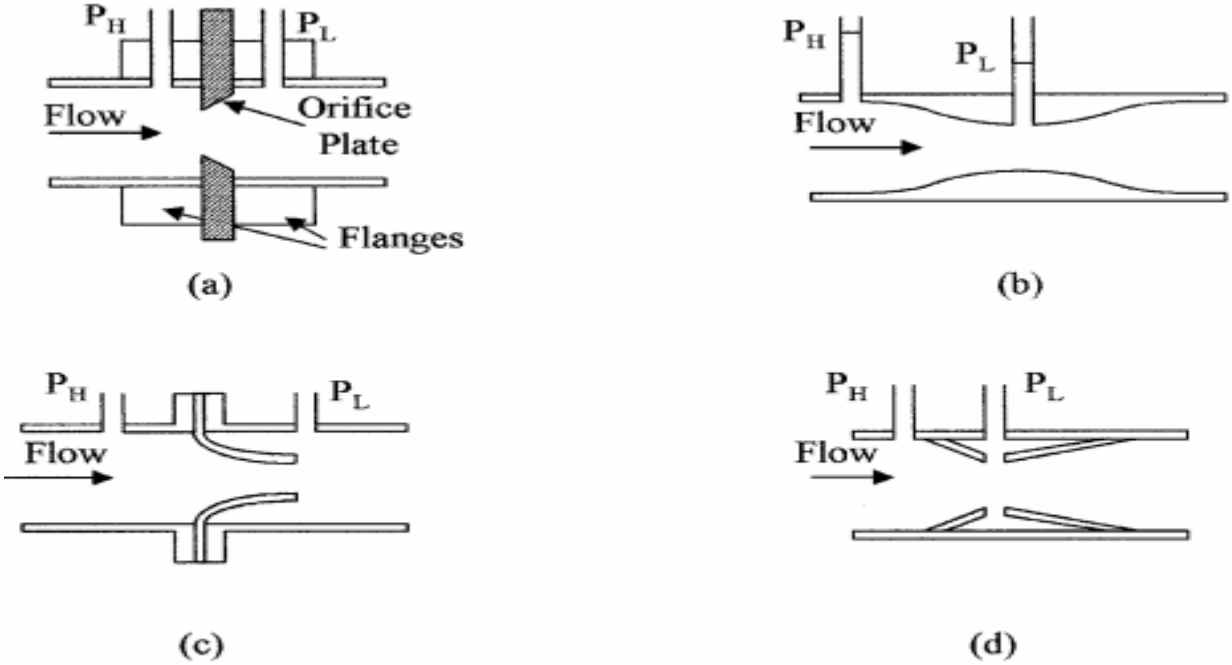
Flow measurements are normally indirect measurements using differential pressures to measure the flow rate. Flow measurements can be divided into the following groups:

(flow rate, total flow, and mass flow).

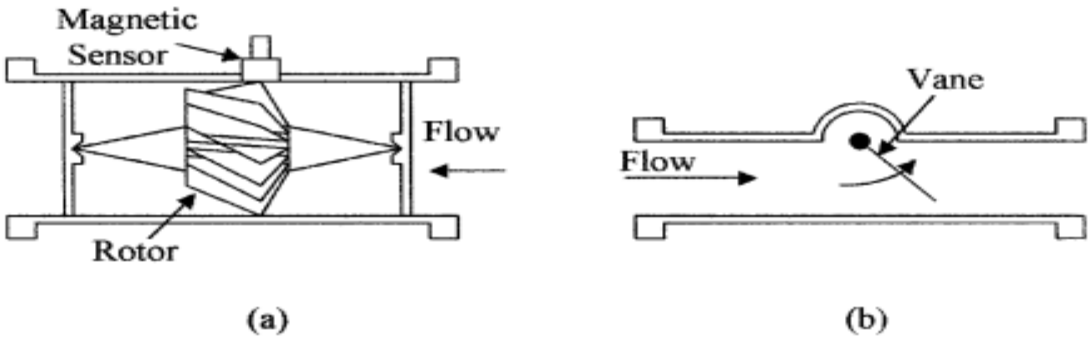
The choice of the measuring device will depend on the required accuracy and fluid characteristics (gas, liquid, suspended particulates, temperature, viscosity, and so on.

►by Flow rate

Differential pressure measurements can be made for flow rate determination when a fluid flows through a restriction.



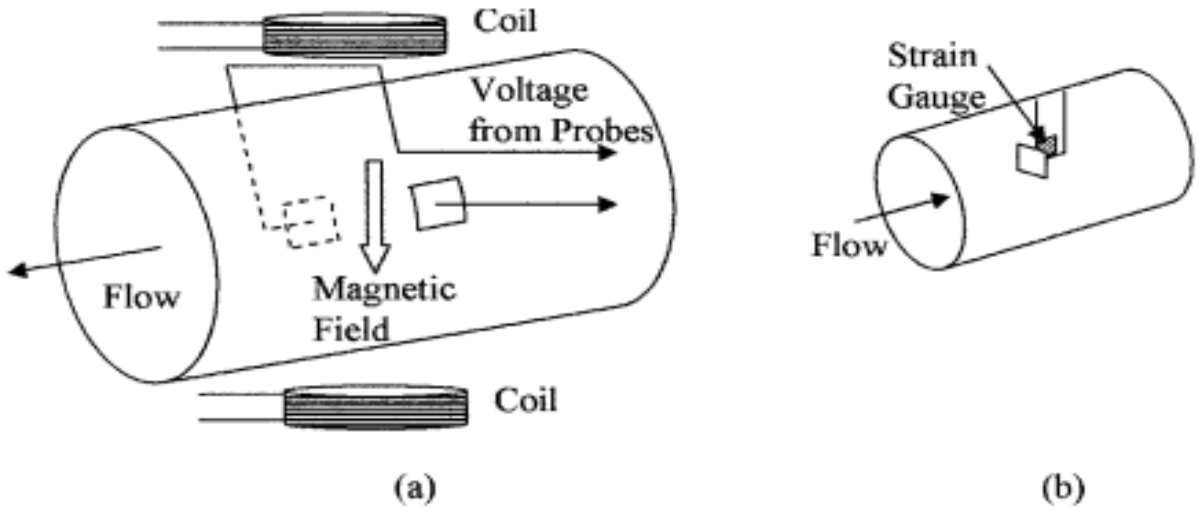
Types of constrictions used in flow rate measuring devices (*a*) orifice plate, (*b*) Venturi tube, (*c*) flow nozzle, and (*d*) Dall tube.



Flow rate measuring devices (*a*) turbine and (*b*) moving vane.

►by Total flow

Includes devices used to measure the total quantity of fluid flowing or the volume of liquid in a flow. Positive displacement meters use containers of known size, which are filled and emptied for a known number of times in a given time period to give the total flow volume. Two of the more common instruments for measuring total flow are the piston flow meter and the mutating disc flow meter.



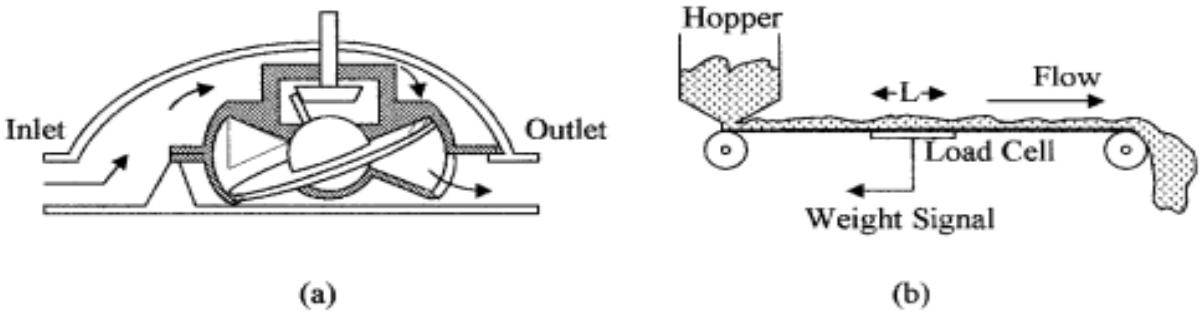
Flow measuring devices shown are (*a*) magnetic flow meter and (*b*) strain gauge flow meter.

►by Mass flow

By measuring the flow and knowing the density of a fluid, the mass of the flow can be measured. Mass flow instruments include constant speed impeller turbine wheel-spring combinations that relate the spring force to mass flow and devices that relate heat transfer to mass flow.

Anemometer is an instrument that can be used to measure gas flow rates. One method is to keep the temperature of a heating element in a gas flow constant and measure the power required. The higher the flow rate, the

higher the amount of heat required. The alternative method (hot-wire anemometer) is to measure the incident gas temperature and the temperature of the gas downstream from a heating element; the difference in the two temperatures can be related to the flow rate. Micro-machined anemometers are now widely used in automobiles for the measurement of air intake mass. The advantages of this type of sensor are that they are very small, have no moving parts, pose little obstruction to flow, have a low thermal time constant, and are very cost effective along with good longevity.



Illustrations show (*a*) the cross section of a nutating disc for the measurement of total flow and (*b*) conveyer belt system for the measurement of dry particulate flow rate.

4-Temperature and Heat measurement:

Temperature is a measure of the thermal energy in a body, which is the relative hotness or coldness of a medium and is normally measured in degrees using one of the following scales; Fahrenheit (F), Celsius or Centigrade (C), Rankine (R), or Kelvin (K). Absolute zero is the temperature at which all molecular motion ceases or the energy of the molecule is zero.

►Temperature Measuring Devices

There are several methods of measuring temperature that can be categorized

as follows:

1. Expansion of a material to give visual indication, pressure, or dimensional change

2. Electrical resistance change

3. Semiconductor characteristic change

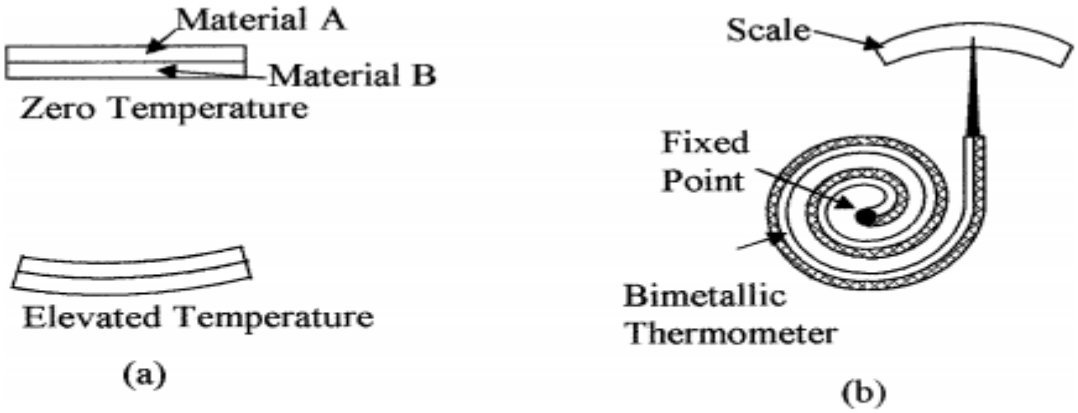
4. Voltage generated by dissimilar metals

5. Radiated energy Thermometer is often used as a general term given to devices for measuring temperature. Examples of temperature measuring devices are described below.

► Thermometers

Mercury in glass was by far the most common direct visual reading thermometer (if not the only one). The device consisted of a small bore graduated glass tube with a small bulb containing a reservoir of mercury. The coefficient of expansion of mercury is several times greater than the coefficient of expansion of glass, so that as the temperature increases the mercury rises up the tube giving a relatively low cost and accurate method of measuring temperature. Mercury also has the advantage of not wetting the glass, and hence, cleanly traverses the glass tube without breaking into globules or coating the tube. The operating range of the mercury thermometer is from −30 to 800°F (−35 to 450°C) (freezing point of mercury −38°F [−38°C]). The toxicity of mercury, ease of breakage, the introduction of cost effective, accurate, and easily read digital thermometers has brought about the demise of the mercury thermometer.

► **Bimetallic strip** :is a type of temperature measuring device that is relatively inaccurate, slow to respond, not normally used in analog applications to give remote indication, and has hystersis. The bimetallic strip is extensively used in ON/OFF applications not requiring high accuracy, as it is rugged and cost effective. These devices operate on the principle that metals are pliable and different metals have different coefficients of expansion (If two strips of dissimilar metals such as brass and invar (copper-nickel alloy) are joined together along their length, they will flex to form an arc as the temperature changes; this is shown in Fig. 8.3a. Bimetallic strips are usually configured as a spiral or helix for compactness and can then be used with a pointer to make a cheap compact rugged thermometer Their operating range is from −180 to 430°C and can be used in applications from oven thermometers to home and industrial control thermostats.



Shows (*a*) the effect of temperature change on a bimetallic strip and (*b*) bimetallic strip thermometer.

► Pressure-spring thermometers:

These thermometers are used where remote indication is required, as opposed to glass and bimetallic devices which give readings at the point of detection. The pressure-spring device has a metal bulb made with a low coefficient of expansion material with a long metal tube, both contain material with a high coefficient of expansion; the bulb is at the monitoring point. The metal tube is terminated with a spiral Bourdon tube pressure gage (scale in degrees) The pressure system can be used to drive a chart recorder, actuator, or a potentiometer wiper to obtain an electrical signal. As the temperature in the bulb increases, the pressure in the system rises, the pressure rise being proportional to the temperature change. The change in pressure is sensed by the Bourdon tube and converted to a temperature scale. These devices can be accurate to 0.5 percent and can be used for remote indication up to 100 m but must be calibrated, as the stem and Bourdon tube are temperature sensitive. There are three types or classes of pressure-spring devices.

►Resistance temperature devices:

Resistance temperature devices (RTD) are either a metal film deposited on a former or are wire-wound resistors. The devices are then sealed in a glass-ceramic composite material. The electrical resistance of pure metals is positive, increasing linearly with temperature. Table 8.5 gives the temperature coefficient of resistance of some common metals used in resistance thermometers. These devices are accurate and can be used to measure temperatures from −300 to 1400°F (−170 to 780°C).

► Thermocouples:

Thermocouples are formed when two dissimilar metals are joined together to form a junction. An electrical circuit is completed by joining the other ends of the dissimilar metals together to form a second junction. A current will flow in the circuit if the two junctions are at different temperatures

The current flowing is the result of the difference in electromotive force developed at the two junctions due to their temperature difference. In practice, the voltage difference between the two junctions is measured; the difference in the voltage is proportional to the temperature difference between the two junctions. Note that the thermocouple can only be used to measure temperature differences. However, if one junction is held at a reference temperature the voltage between the thermocouples gives a measurement of the temperature of the second junction.

Three effects are associated with thermocouples. They are as follows:

1.Seebeck effect : It states that the voltage produced in a thermocouple is proportional to the temperature between the two junctions.

2.Peltier effect: It states that if a current flows through a thermocouple one junction is heated (puts out energy) and the other junction is cooled (absorbs energy).

3.Thompson effect: It states that when a current flows in a conductor along which there is a temperature difference, heat is produced or absorbed, depending upon the direction of the current and the variation of temperature.

Process Control

►Basic Terms

Some of these terms have already been defined, but apply to this chapter. Hence, the terms are redefined here for completeness.

●*Lag time* : is the time required for a control system to return a measured variable to its set point after there is a change in the measured variable, which could be the result of a loading change or set point change and so on.

●*Dead time* :is the elapse time between the instant an error occurs and when the corrective action first occurs.

●*Dead-band* : is a set hysteresis between detection points of the measured variable when it is going in a positive or a negative direction. This band is the separation between the turn ON set point and the turn OFF set point of the controller and is sometimes used to prevent rapid switching between the turn ON and turn OFF points.

●*Set point*: is the desired amplitude of an outpoint variable from a process.

●*Error signal*: is the difference between a set reference point and the amplitude of the measured variable.

●*Transient*: is a temporary variation of a load parameter after which the parameter returns to its nominal level.

●*Measured variable*: is an output process variable that must be held within given limits.

●*Controlled variable*: is an input variable to a process that is varied by a valve to keep the output variable (measured variable) within its set limits.

●*Variable range*: is the acceptable limits within which the measured variable must be held and can be expressed as a minimum and a maximum value, or a nominal value (set point) with ±spread (percent).

●*Control parameter range*: is the range of the controller output required to control the input variable to keep the measured variable within its acceptable range.

●*Offset* : is the difference between the measured variable and the set point after a new controlled variable level has been reached. It is that portion of the error signal which is amplified to produce the new correction signal and produces an “Offset” in the measured variable.

►Control Modes:

The two basic modes of process control are ON/OFF action and “continuous control” action. In either case the purpose of the control is to hold the measured variable output from a process within set limits by varying the controlled inputvariable to the process.
In the case of ON/OFF control (discrete control or two position control), the output of the controller changes from one fixed condition (ON) to another fixed position (OFF). Control adjustments are the set point and in some applications a dead-band is used. In continuous control (modulating control) action the feed-back controller determines the error between a set point and a measured variable. The error signal is then used to produce an actuator control signal to operate a valve and reduce the error signal. This type of control continuously monitors the measured variable and has three modes of operation which are proportional, integral, and derivative. Controllers can use one of the functions, two, or all three of the functions as required.