Centre for Continuing Education

PROCESS DESIGN EXECUTION METHODOLOGY OF OIL & GAS, PETROCHEMICALS AND REFINERY PROJECTS

By

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&

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Guide By

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A DISSERTATION ON REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

MBA (OIL & GAS MANAGEMENT)

OF

CENTRE FOR CONTINUING EDUCATION

UNIVERSITY OF PETROLEUM & ENERGY STUDIES, DEHRADUN

Acknowledgement

This is to acknowledge with thanks the help, guidance and support that I have received during the Dissertation.

I have no word to express a deep sense of gratitude to the management of **UPES** for giving me an opportunity to pursue my Dissertation, and in particular **Dr. Dinesh S. Butada (Associate Professor)**, for his able guidance and support.

I must also thanks **Mr. Sushil Jibhkate** & **Mr. Shernik Gat** for their valuable support.

I also place on record my appreciation of the support provided by **Mr. Ganesh R. Jogi** and other staff of my office library.

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Declaration by the Guide

This is to certify that the **Mr. Pramod Balaji Zade**, a student of **MBA (Oil & GasManagement)**, SAP ID **500070401** of UPES has successfully completed this dissertation report on **"Process Design Execution Methodology of Oil & Gas, Petrochemicals and Refinery Projects"** under my supervision.

Further, I certify that the work is based on the investigation made, data collected and analyzed by him and it has not been submitted in any other University or Institution for award of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfillment for the award of degree of MBA.

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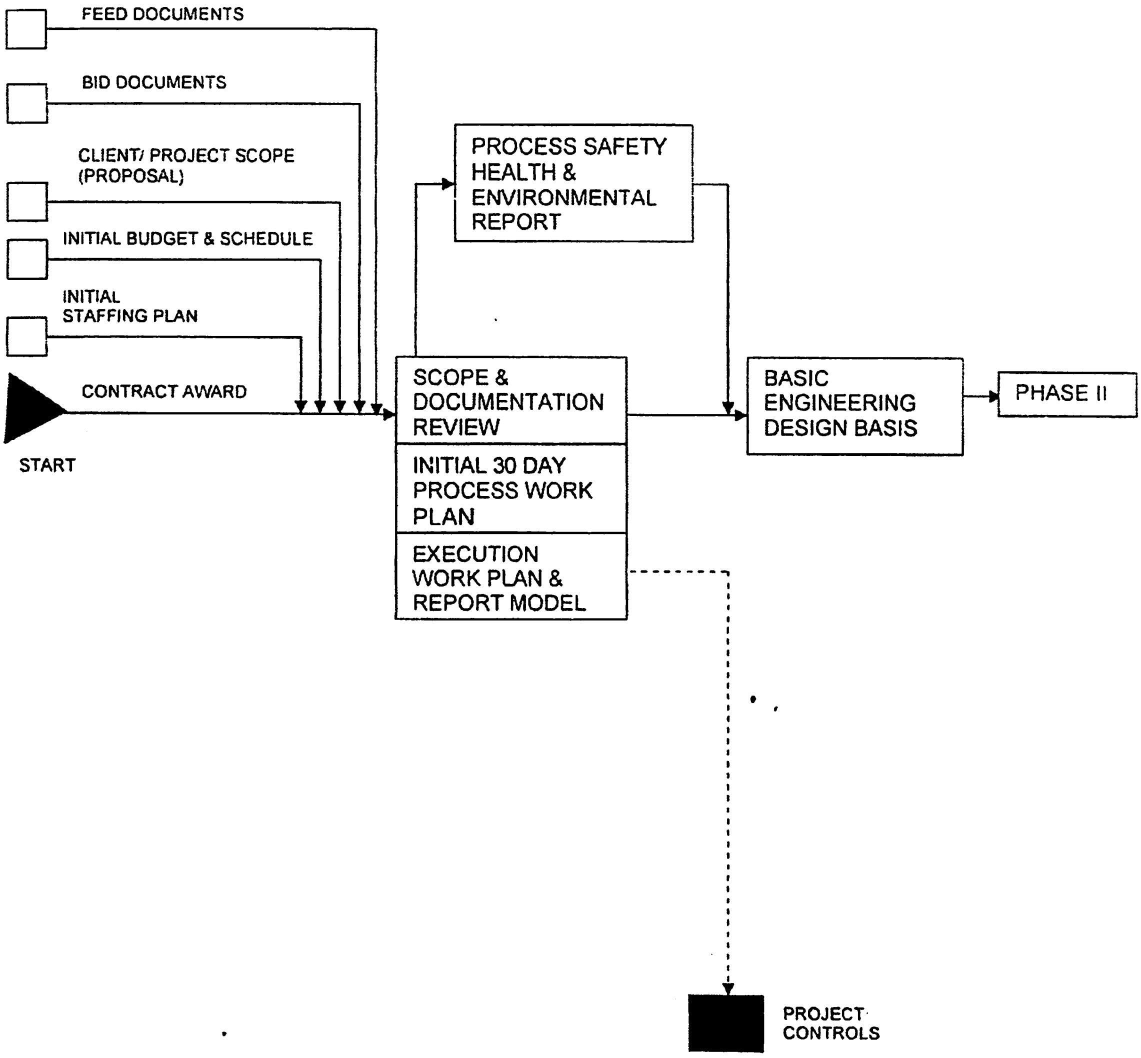


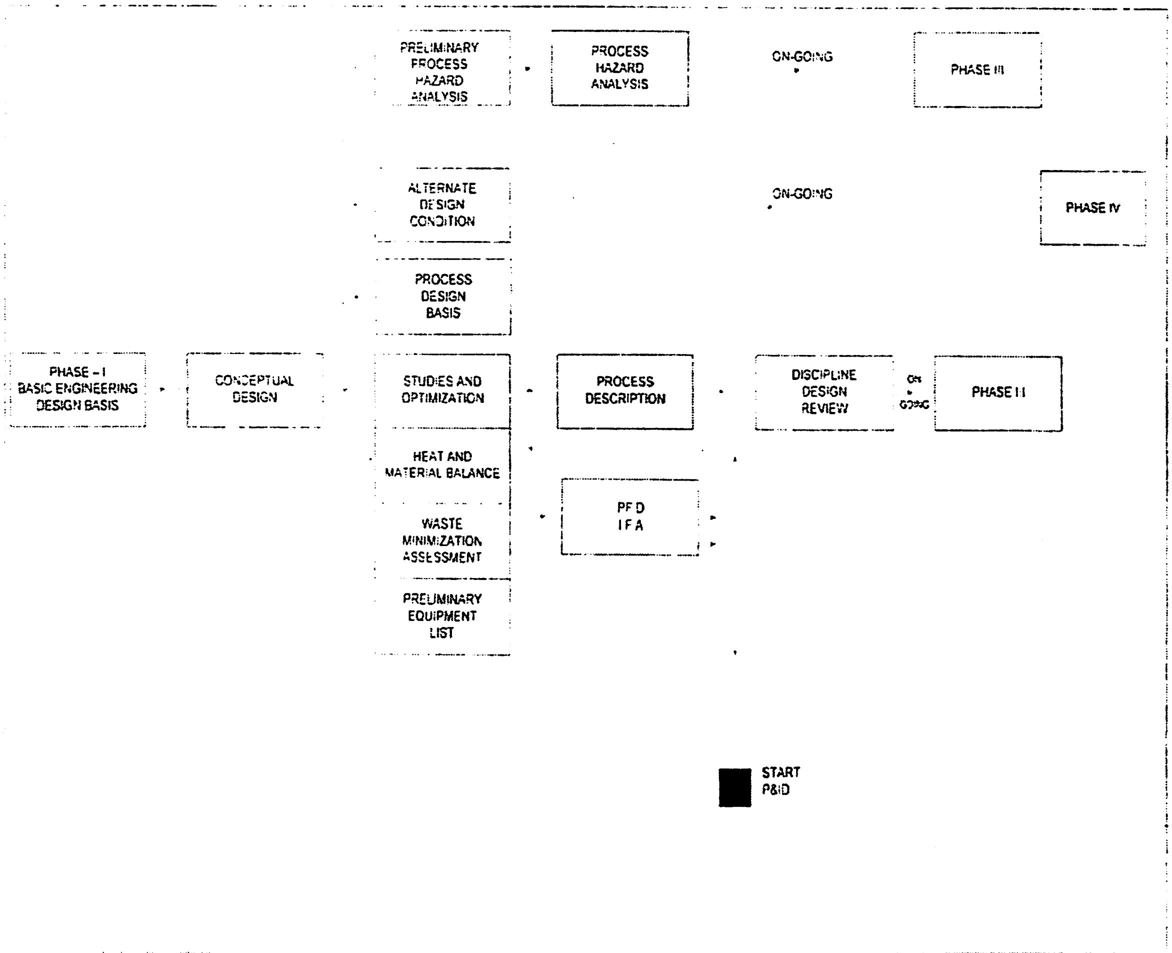
Attachment 2- Work Flow Matrix for "Design Initiation".

WORK FLOW MATRIX
PHASE 1: DESIGN INITIATION

SUPPLIER: C/S/A	CLIENT	ELECTRICAL	INSTR/CONTROL	MECHANICAL	PL&P	PROCESS	PROCUREMENT	PROJECT	PROJ CONTROLS	INPUT	OUTPUT	CUSTOMER: C/S/A	CLIENT	ELECTRICAL	INSTR/CONTROL	MECHANICAL	DEFINE	PROCESS	PROCUREMENT	PROJECT	PROJ CONTROLS
	X							X		Project Scope											
	X					X		X		FEED Documents											
								X		Bid Documents											
	X					X		X		Engineering Standards											
											Scope and Document Review							X			
						X				Scope and Document Review											
											Process Safety, Health and Environ, Report (PSHER)							X			
						X				Scope and Document Review											
											Initial 30-Day Process Work Plan							X		X	X
						X				Scope and Document Review											
						X				PSHER											
											Basic Engineering Design Basis	X	X	X	X	X	X	X	X	X	X
						X				Basic Engineering Design Basis											
	X							X	X	Project Schedule											
						X				Initial 30-Day Process Workplan											
						X				Number of PFDs											
						X				Major Equipment Count											
						X		X		Number of P&IDs											
											Execution Workplan & Reporting Model								X	X

Attachment 3 - Block Flow Diagram for "Design Development".

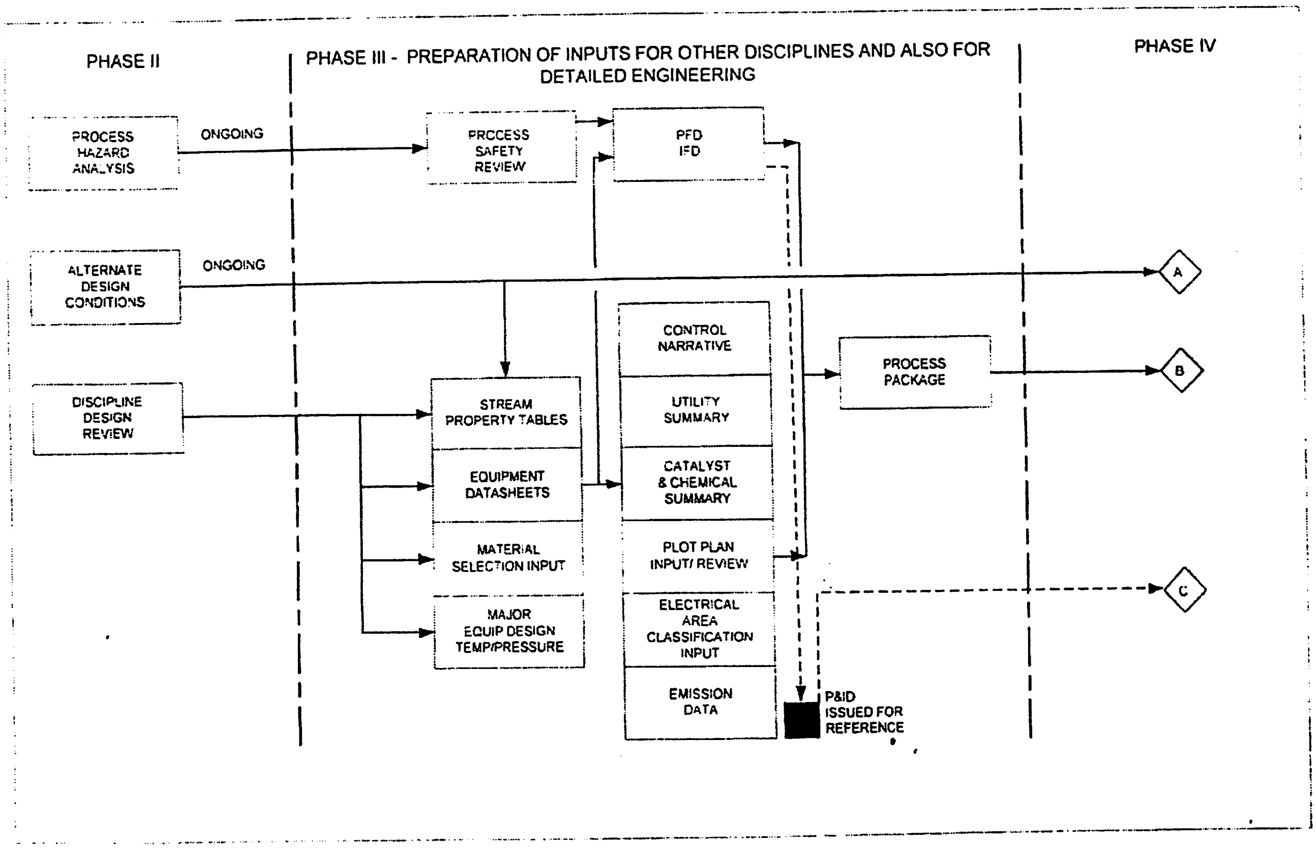
PROCESS DESIGN EXECUTION-MAJOR PROJECT FLOW SCHEME



Attachment 4 - Work Flow Matrix for "Design Development".

SUPPLIER										WORK FLOW MATRIX PHASE II - DESIGN DEVELOPMENT		CUSTOMER									
C/S/A	CLIENT	ELECTRICAL	INSTR/CONTROL	MECHANICAL	PL&P	PROCESS	PROCUREMENT	PROJECT	PROJ CONTROLS	INPUT	OUTPUT	C/S/A	CLIENT	ELECTRICAL	INSTR/CONTROL	MECHANICAL	PL&P	PROCESS	PROCUREMENT	PROJECT	PROJ CONTROLS
	X									Client/Licensor Information											
						X				Basic Engineering Design Basis											
										FEED Documents	Conceptual Design							X			
						X				Conceptual Design	Preliminary Hazard Analysis										
											PreHA							X			
						X				Preliminary Hazard Analysis	Process Hazard Analysis										
										PreHA	ProHA							X			
						X				Conceptual Design											
											Alternate Design Condition							X			
						X				Conceptual Design											
											Studies & Optimization		X					X		X	
						X				Studies & Optimization											
											Heat & Material Balance							X			
						X				Design Review											
	X					X		X		Environment Data											
						X				Process Design Basis											
											Waste Minimization Accessment							X			
						X				Conceptual Design											
											Preliminary Equipment List	X	X	X	X	X	X	X	X	X	X
						X				Studies and Optimization											
			X			X				Control Philosophy											
						X				Heat & Material Balance											
	X							X		Standard Symbols											
	X					X				PFD Format											
											PFDs (IFA)	X	X	X	X	X	X	X	X	X	
						X				PFDs(IFA)											
						X				Alternate Design Conditions											
						X				Studies & Optimization											
											Process Description	X	X	X	X	X	X	X	X	X	X
						X				PFDs (IFA)											
						X				Process Description											
											Discipline Design Review	X		X	X	X	X	X		X	

Attachment 5 - Block Flow Diagram for "Preparations of Inputs for other Discipline and also for Detailed Engineering".



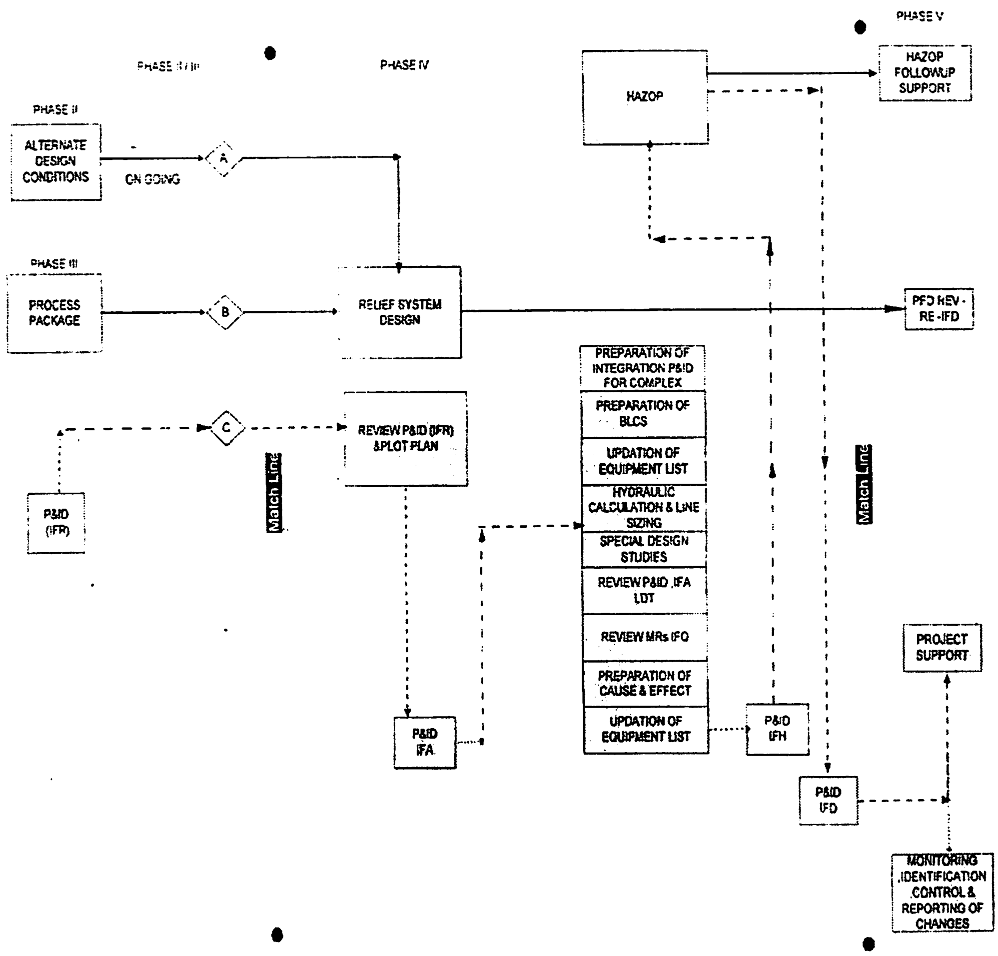
Attachment 6 - Work Flow Matrix for "Preparations of Inputs for other Discipline and also for Detailed Engineering".

WORK FLOW MATRIX

PHASE III - PREPARATION OF INPUTS FOR OTHER DISCIPLINES AND ALSO FOR DETAILED ENGG.

SUPPLIER												CUSTOMER									
C/S/A	CLIENT	ELECTRICAL	INSTR/CONTROL	MECHANICAL	PL & PIPING	PROCESS	PROCUREMENT	PROJECT	PROJ CONTROLS	INPUT	OUTPUT	C/S/A	CLIENT	ELECTRICAL	INSTR/CONTROL	MECHANICAL	PL & PIPING	PROCESS	PROCUREMENT	PROJECT	PROJ CONTROLS
						X				PFDs (IFA)											
						X				Process design basis											
	X					X		X		Battery limit conditions											
	X					X				Physical property database											
						X				Alternate design conditions											
						X					Stream property table				X	X	X	X			
						X				Equipment list											
						X				Stream property table											
						X				PFDs (IFA)											
						X				Process design basis											
						X				Heat and material balance											
	X					X		X		Site data											
	X					X		X		Utility data											
						X				Alternate design conditions											
											Equipment datasheets	X		X	X	X	X	X		X	
						X				Stream property table											
						X				PFDs (IFA)											
						X				Process Safety information											
											Material selection input									X	
						X				Process design basis											
						X				PFDs (IFA)											
						X				Heat and material balance											
						X				Alternate design conditions											
						X				Stream property table											
											Equip. Design Temp. & Pr input					X		X		X	
						X				Process Hazard analysis											
											Process Safety review							X			
						X				PFDs (IFA)											
	X									Client comments/approval											
				X		X		X		Design development											
											PFDs (IFD)	X	X	X	X	X	X	X	X	X	
			X			X				Control philosophy											
					X	X				Preliminary site plan											
						X				PFDs											
				X		X		X		Equipment design data											
						X				Process Safety information											
											Proc. Control & Logic philosophy				X	X		X		X	
	X					X		X		Utility data											
						X				PFDs											
						X				Heat and material balance											
				X		X		X		Equipment data											
											Utility summary			X				X		X	

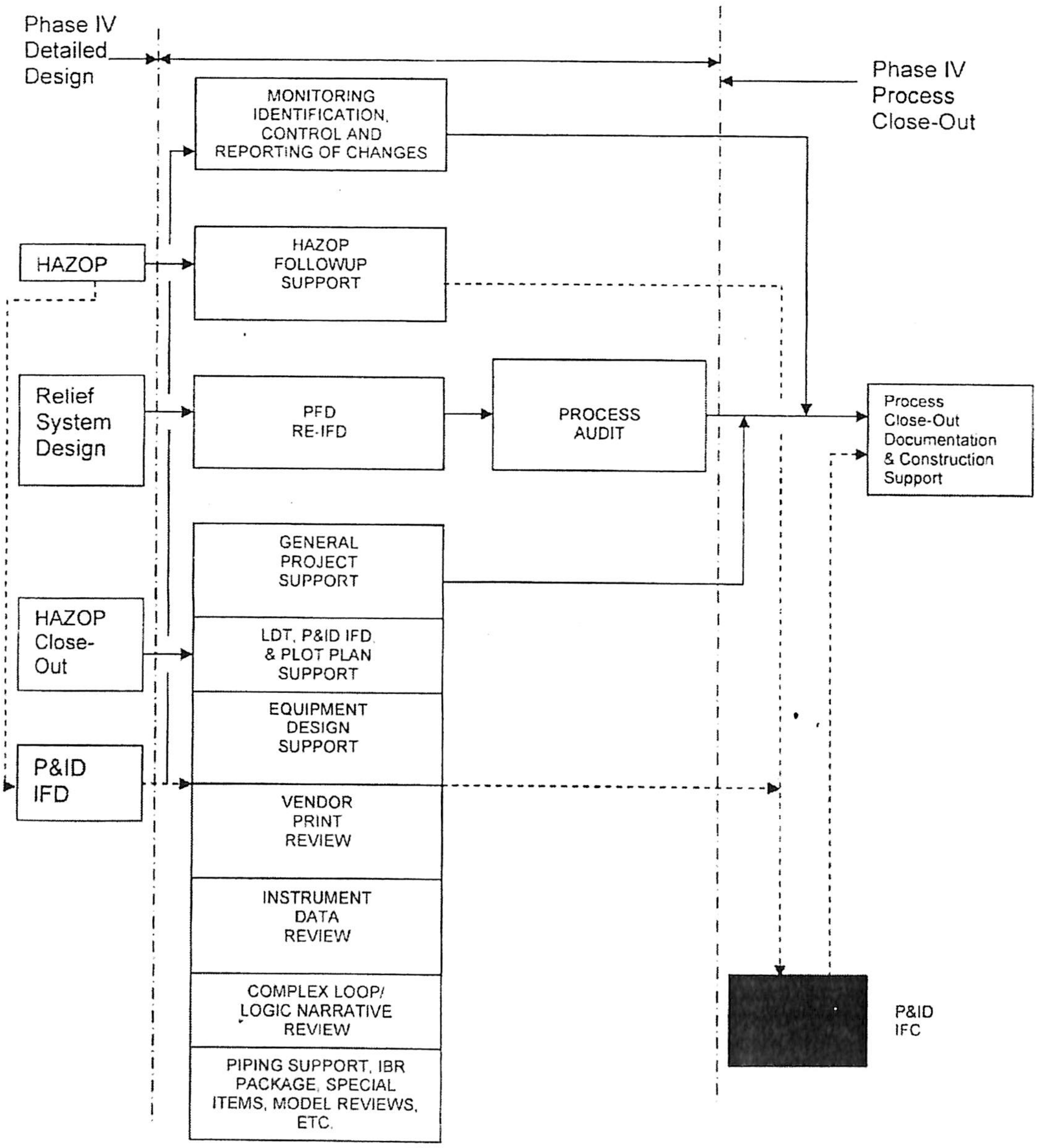
Attachment 7 - Block Flow Diagram for "Detailed Design"



Attachment 8 - Work Flow Matrix for "Detailed Design"

CSA	CLIENT	ELECTRICAL	INSTR CONTROL	MECHANICAL	PL&P	PROCESS	PROCUREMENT	PE MANAGER	PROJECT	PROJECT CONTROLS	INPUT	OUTPUT	CSA	CLIENT	ELECTRICAL	INSTR CONTROL	MECHANICAL	PL&P	PROCESS	PROCUREMENT	PE MANAGER	PROJECT	PROJECT CONTROLS
											PROCESS ENGINEERING DETAILED DESIGN - PAHSE - IV		CUSTOMER										
									X		P&IDs (IFR)												
									X		Line Designation Table												
					X						Plot plans /Model												
						X					PFD (IFD)												
						X					Stream Properties Table												
												Review P&ID(IFR) & Plot Plan						X	X			X	
	X					X			X		Relief / BD Philosophy												
						X					PFDs (IFD)												
						X					Process Design Basis												
	X					X					Physical Property Database												
	X					X			X		Site data												
						X					Process Safety Information												
						X		X			Environmental Data												
						X					Relief Valve/Load data												
									X		P&IDs (IFA)												
					X						GAs /Plot Plans (IFA)												
												Relief System Design						X	X	X		X	
						X					PFDs (IFD)												
						X					Process Design Basis												
						X					Stream Properties Table												
									X		P&IDs (IFA)												
					X						GAs /Plot Plans												
						X					Alternate Design Conditions												
									X		Pump & Compr Calc sheets												
				X		X					Equipment Data Sheets												
												Special Design Studies including Hydraulic Calculation & Profiles							X			X	
				X		X					Equipment Data Sheets & Specs												
									X		P&IDs (IFA)												
					X						Plot Plans												
				X			X				Material Requisition	Equipment Bid Tab Support					X		X	X			
									X		P&IDs (IFA)												
									X		Line Designation Table												
					X						Plot Plans /Model												
						X					PFDs (IFD)												
						X					Stream Properties Table	Review LDT P&Id (IFR) & Plot Plan						X	X			X	
						X					Relief System Design												
						X					Alternate Design Conditions												
									X		P&IDs (IFH)												
						X					PFDs (IFD)												
				X		X					Equipment Data Sheets												
					X						GAs / Plot plans(IFA)	HAZOP		X					X			X	

Attachment 9 - Block Flow Diagram for "Project Support".

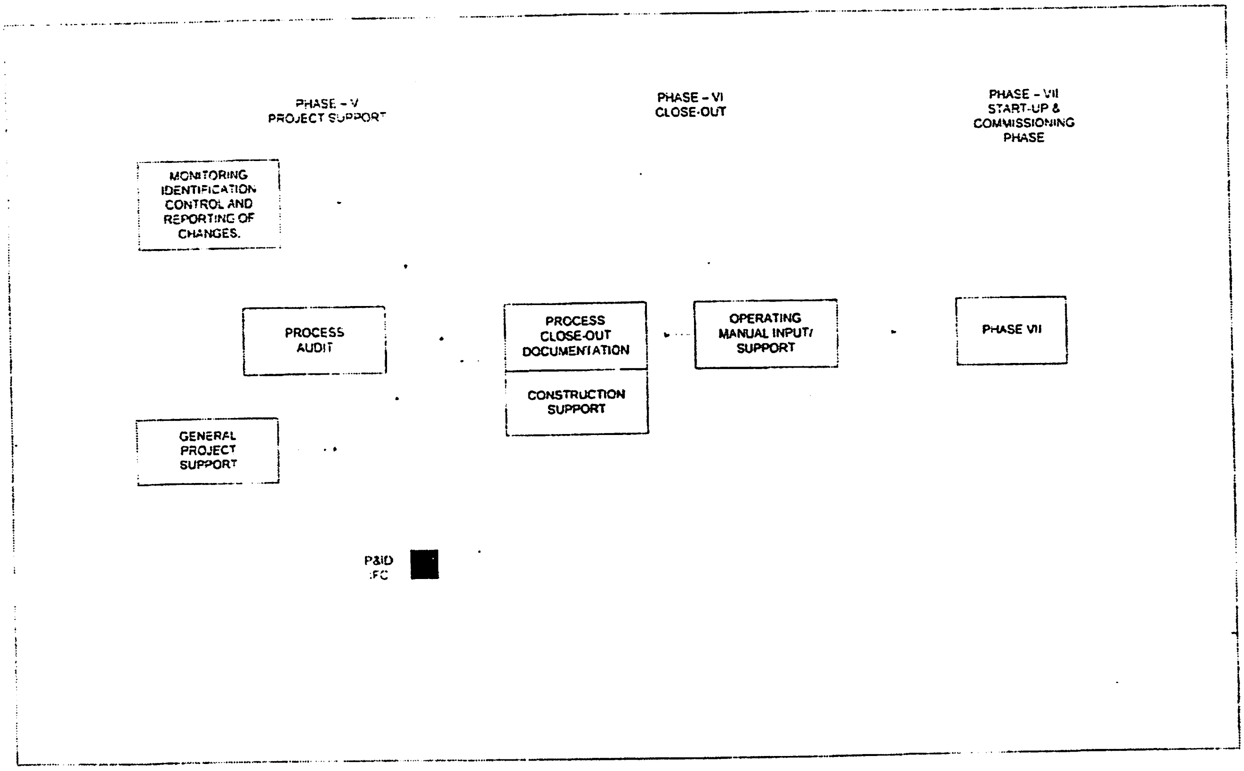


Attachment 10 - Work Flow Matrix for "Project Support".

PROCESS ENGINEERING
WORK FLOW MATRIX
PHASE V PROJECT SUPPORT

SUPPLIER: CSA	CLIENT	ELECTRICAL	INSTRUMENT/CONTROL	MECHANICAL	PL&P	PROCESS	PROCUREMENT	PE MANAGER	PROJECT	PROJ CONTROLS	INPUT	OUTPUT	CUSTOMER: CSA	CLIENT	ELECTRICAL	INSTRUMENT/CONTROL	MECHANICAL	PL&P	PROCESS	PROCUREMENT	PE MANAGER	PROJECT	PROJ CONTROLS
	X					X					Hazop Result	Monitoring identify Control & Reporting of changes							X		X		
	X					X					Hazop Result												
									X		P&IDs(IFH)												
				X		X					Equipement Data Sheets & specs												
												HAZOP Follow-up Support		X							X	X	
						X					PFDs(IFD)												
X	X	X	X	X	X	X			X		Design Discipline Comments												
				X		X					Equipement Data Sheets & Specs												
												PFDs, Re-IFD	X	X	X	X	X	X	X	X	X	X	
				X							Detailed Equipment Specs												
			X	X	X			X	X		General Specs												
				X		X					Equipment Data Sheets												
				X			X				Material Requisitions/POs												
						X					PFDs (Re-IFD)												
									X		P&IDs (IFD)												
						X					Stream Properties Table												
					X						GAs/Plot Plans												
						X					Process Safety Information												
	X					X			X		Site Data												
	X					X			X		Utility Data												
								X			Environmental Data												
	X										Client Comments												
								X			Construction Plans												
												General Project Support	X	X	X	X	X	X	X	X	X	X	X
									X		P&IDs (IFD)												
					X						Plot Plans/Model												
												LDT, P&ID, & Plot Plan Support						X	X			X	
								X			Vendor Prints												
				X		X					Equipment Data Sheets & Specs												
									X		P&IDs (IFD)												
				X				X	X		Project Specifications												
												Equipment Design Support					X	X	X	X	X	X	
	X					X					HAZOR												
				X		X					Equipment Data Sheets & Specs												
									X		P&IDs (IFD)												
								X			Vendor Prints												
												Vendor Prints Review					X		X	X	X	X	
			X								Instrument Data Sheets												
						X					Stream Property Table												
						X					Alternate Design Condition												
												Instrument Data Review				X			X		X	X	
			X								Complex Loop Description												
			X								Logic Narrative												
	X		X					X			Instrument Specification												
						X					Process Control & Logic Phi												
									X		P&IDs (IFD)												
												Complex Loop/Logic Narrative Review			X								
						X					Process Design Package												
									X		P&IDs (IFD)												
					X						Plots Plans												
						X					Relief System Design												
	X					X					HAZOP												
						X					Waste Minimization Assessement												
												Process Audit							X		X		

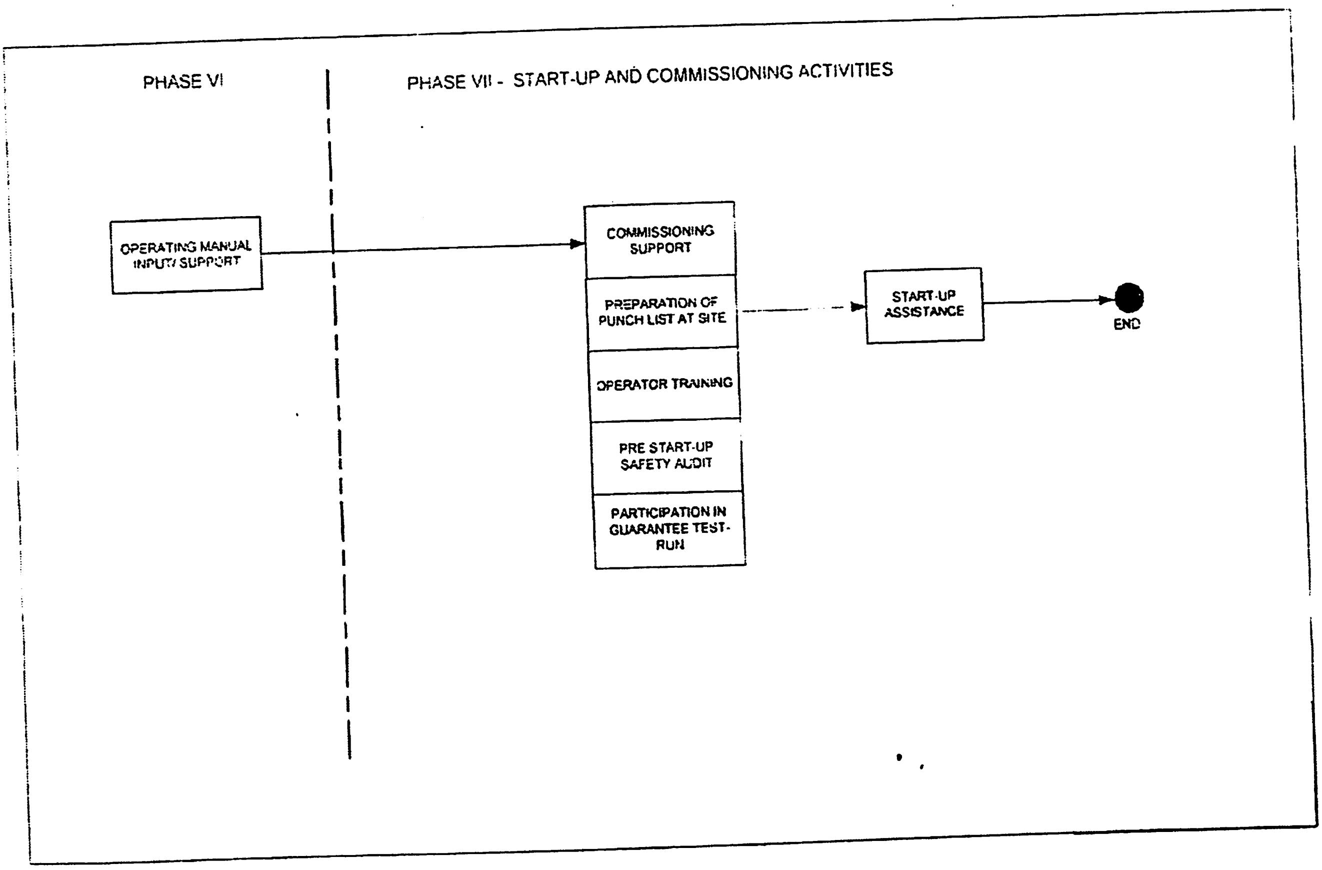
Attachment 11 - Block Flow Diagram for "Close-Out".



Attachment 12 - Work Flow Matrix for "Close-Out".

SUPPLIER											WORK FLOW MATRIX PHASE VI - CLOSE-OUT		CUSTOMER										
C/S/A	CLIENT	ELECTRICAL	INSTR/CONTROL	MECHAN.CAL	PL&P	PROCESS	PROCUREMENT	PE MANAGER	PROJECT	PROJ CONTROLS	INPUT	OUTPUT	C/S/A	CLIENT	ELECTRICAL	INSTR/CONTROL	MECHAN.CAL	PL&P	PROCESS	PROCUREMENT	PE MANAGER	PROJECT	PROJ CONTROLS
	X					X		X	X		Job Files												
						X					Process Reference Files												
						X					Process Scope												
						X				X	Project Schedule												
						X					Calculation Files												
						X					Filing Index												
								X			Project Close-out Procedure												
						X					Process Audit												
						X					HAZOP												
												Close-out Documentation							X		X		
							X	X	X		Field Request/Clarification												
												Construction Support							X		X	X	
									X		P&IDs(IFC)												
						X					PFDs												
						X					Process Description												
						X					Control Philosophy/PCD's												
						X					Process Design Package												
				X		X					Equipment Data Sheets & Specs												
								X			Vendor Prints												
												Operating Manual Support							X		X		

Attachment 13 - Block Flow Diagram for "Start-Up & Commissioning Activities".



Attachment 14 - Work Flow Matrix for "Start-Up & Commissioning Activities".

SUPPLIER											WORK FLOW MATRIX PHASE VII - START-UP AND COMMISSIONING ACTIVITIES		CUSTOMER										
C/S/A	CLIENT	ELECTRICAL	INSTR/CONTROL	MECHANICAL	PL & P	PROCESS	PROCUREMENT	PE MANAGER	PROJECT	PROJ CONTROLS	INPUT	OUTPUT	C/S/A	CLIENT	ELECTRICAL	INSTR/CONTROL	MECHANICAL	PL & P	PROCESS	PROCUREMENT	PE MANAGER	PROJECT	PROJ CONTROLS
						X					Process design package												
									X		P&IDs (IFC)												
					X						GA drawings/Plot plans												
						X					Relief system design												
	X					X					PSHES, PreHA, ProHA, HAZOP												
	X								X		Operating manual												
							X				Vendor prints												
												Pre start-up safety audit report		X							X		
	X							X	X		Commissioning												
	X			X				X	X		Equipment testing												
	X							X			Inventory												
												Pre-operations support		X							X		
	X							X			Operating manual												
						X					Process design package												
												Operator training		X							X		
									X		P&IDs (IFC)												
						X					PFDs (IFD)												
					X						GA drawings/Plot plans												
						X					Safety information												
				X		X					Equipment datasheets & specs												
	X			X		X		X			Project & Process guarantees												
								X			Vendor prints												
												Start-up Assistance		X					X		X		

5. EXECUTIVE SUMMARY / ABSTRACT :

This dissertation report is to define the Process Engineering activities and deliverables involved in the execution of major project. This report is to be used as the standard reference methodology for all Process Design work of Oil & Gas, Petrochemicals and Refinery. This will ensure consistent quality deliverables to both inter-departmental and external customers/client.

The Process Manager/Lead Process Engineers will need to customize this methodology for each job based on the commencement point and the particular requirements of the contract. Process Engineering responsibility for the execution of major projects can be divided into two main broad categories namely **Basic & Detailed Engineering** with each category containing several phases. These phases are,

1) BASIC ENGINEERING

Phase I - Design Initiation

Phase II - Design Development

Phase III - Preparations of inputs for other discipline and also for detailed engineering.

2) DETAILED ENGINEERING

Phase IV - Detailed Design

Phase V - Project Support

Phase VI - Close-Out

Phase VII - Start-Up & Commissioning Activities

The Process Design Execution methodology gives general guidelines for process engineer to execute the project but the responsibility to prepare documents totally depends on the type of job or nature of contract with client & scope limitation for engineering work for the project.

6. CHAPTERS / DETAILS STUDY OF EXECUTION METHODOLOGY:

The details of phases for execution of major project of Oil & Gas, Petrochemicals and Refinery, as per the standard reference methodology for all Process Design work describe in the following phases,

1. PHASE I : DESIGN INITIATION

The details of responsibilities associated with design initiation phase are described in the work process/procedure.

Work Process/Procedure

This guide contains:

(a) a narrative describing each design initiation phase,

(b) a block flow diagram **(Attachment 1)** indicating the work flow logic, the approximate sequence of the activities, and their relationship to key project interfaces and milestones.

(c) a work flow matrix **(Attachment 2)** identifying the flow of information to and from Process Engineering suppliers and customers.

1.1 Scope and Documents Review

The lead process engineer (LPE) reviews the proposal, the contract and other available information pertaining to the initial project scope, budget, schedule and staffing plan.

The LPE reviews the scope and available documentation with the process team members for the purpose of orienting the team members as well as identifying any additional scope definition required from the client/licensor. Also add or clear the scope from client or Project Management Consultant.

The LPE also reviews with the team the steps of the standard execution methodology as presented in this procedure, and how this procedure may be customized to meet the specific needs of the project.

The LPE prioritizes initial work activities for the team according to the schedule prepared by LPE for project execution from IDC to As-Built or depending on the scope for Detailed Engineering.

1.2 Process Safety, Health and Environment Report

The Lead Environmental Engineer(LEE)is responsible for issuing a Process Safety, Health and Environmental Report (PSHER). This report can be included in the Basic Engineering Design Basis document.

This report is generally prepared based on client requirement.

The purpose of the PSHER is to provide early identification of area that will require special safety, health and environmental emphasis during the course of process design development. Because of the limited information available this early in the project, the PSHER is essentially a qualitative assessment of potential hazards associated with the material expected to be handle by the process.

The documents identifies the chemicals, process and waste streams that may be encountered. It identifies any special procedure for the handling or processing of these streams and highlights any area of concern that will require careful consideration for operation and dispatch.

1.3 Initial 30 Day Process Work Plan

As soon as possible after the process kick-off meeting the LPE develops and issues a 30 Day Work Plan to the project, This plan outlines the tasks to be performed and the staffing required during the next 30 days or until the initial Basic Engineering Design Basis(BEBD) and the Execution Work Plan for the entire project can be completed. The staffing required for each issue will be clearly mentioned. Also the additional staffing man-hours required if there is possibility of increase the scope of project in future.

1.4 Basic Engineering Design Basis

The LPE assembles and issues the Basic Engineering Design Basis for approval by the client. This document set the qualitative and quantitative premises and specifications upon which the process engineer and the downstream disciplines base their work. The importance of maintaining and up-to-date and accurate Basic Engineering Design Basis to avoid rework cannot be over emphasized.

This document should be revised and reissued as needed to keep it current. The initial issue of the Basic Engineering Design Basis may be general and may lack definition/data in some areas. However, when the final issue for the Process Design Package is produced, the information should be complete and firm.

The Basic Engineering Design Basis will typically include, but not be limited to the following,

- Process scope of work
- Site data including meteorological data, utility conditions and availability, description of existing facilities if any.
- Battery limits conditions
- Environmental constraints.
- Client corporate and local standards and practices that are to be applied to this particular job.
- Determination of DPDT.

1.5 Execution Work Plan

The LPE develops and issues an Execution Work Plan for the Process Engineering Group. The Work Plan defines the Process Deliverables (based on the available scope information) and establishes a schedule indicating when these work product will be generated.

Preparation of this document require assimilating and interpreting the client's objective, identifying the Process task required, and then defining the methods to be used and the deliverables for each task.

The work plan includes:

- A list describing the major Process tasks and deliverables.
- An execution logic describing the timing and sequences of tasks, and the major inputs and output from each task (This methodology can be starting point).
- A schedule indicating the start and finish of each major task. The schedule needs to be coordinated with other disciplines to ensure that realistic project milestones are established.
- Preliminary budgets of many Process hours are required to complete each task.
- A staffing plan describing how many Process hours are required to complete each task.
- A staffing plan describing how many process engineers are required to complete the tasks including estimated mobilization and demobilization dates.
- A statements of requirements for physical facilities such as office space and computing hardware and software.

The Work Plan forms the basis for the Reporting Model used for Engineering Progress and Measurement System. The LPE should interface with the Project Control Administrator to ensure that activity codes for man-hour charges are set up properly to serve the needs of the project as well as support Process Design metrics. The standard set of Engineering Progress and Measurement System activity codes should be used. Deviations from this set are left to the discretion of the Process Manager and LPE.

2. PHASE II : DESIGN DEVELOPMENT

The details of responsibilities associated with design development phase are described in the work process/procedure.

Work Process/Procedure,

This work process describes the basic engineering activities which are to be taken up in continuation with the activities under design initiation phase as described in the document.

This design development guide contains,

(a) a narrative describing each of the Design Development activities,

(b) a block flow diagram **(Attachment 3)** indicating the work flow logic, the approximate sequence of the activities, and their relationship to key project interfaces and milestones, and

(c) a work flow matrix **(Attachment 4)** identifying the flow of information to and from Process Engineering suppliers and customers.

2.1 Conceptual Design

Conceptual design involves selecting the types and sequence of unit operations and processing steps required to achieve the process objectives. In this step, the design may begin with a simple block diagram and then progress to a process flow sketch. The design is refined and evaluated against the project standards and criteria and sound process engineering practices in several categories including.

- Safety
- Environmental
- Operability
- Energy efficiency
- Raw material utilization and waste minimization
- Maintenance considerations
- Capital costs versus operating costs

Many of this categories are revisited throughout the process design development, for example, during the Process Flow Diagram development and during P&ID review.

The Conceptual Design activity may include an evaluation of open art versus licensed technology if the selection has not already been made by the client.

On projects that will utilize licensor packages or existing designs, the conceptual design stage should include an examination of the licensor's design in the context of the clients specific application. In particular, the licensor design basis needs to e compared to the current Process Design Basis to determine if the original assumptions on which the licensor design was based are still valid.

2.2 Process Design Basis

Process Design Basis is a very critical document for a project. It contains all sites specific information to be used during basic as well as detail engineering. The information given in this documents forms the basis for basic and detailed engineering. It defines the responsibility of all the disciplines as well as vendor/Supplier etc. Also it contains the list of codes and standard to be followed for a particular project.

2.3 Alternate Design Conditions

The normal operation design case of the plant is shown on the PFDs and the supplemental design information is provided on stream property table.

However, other operating cases, which may not warrant the production of separate PFDs, may determine the design of particular items of equipment or have an impact on the reliability, safety or economics of the plant. These alternate operating conditions(e.g., excursions in temperature, pressure, or flow) could be the result of seasonal operation, blocked operation, start-up, shutdown, plant upset or special operations (steamout, decoking, regeneration, purging, depressuring, chemical cleaning etc.)

All alternate operating cases should be listed and the impact of each case on equipment design, operability and safety should be documented. It is important that the project team, start-up crew and the clients operation personnel be aware of all alternate operating conditions. Alternate Design Considerations may be issued as

Operational and Start-up considerations and are an essential part of the operating manual.

Alternate design Conditions must be reviewed and updated on an ongoing basis as the mechanical design and P&IDs are developed, with particular attention paid during the relief system design.

2.4 Preliminary Process Hazard Analysis

The LPE is responsible for conducting a Preliminary Hazard Analysis(PreHA).

The purpose of the PreHA is to identify major hazards that could lead to severe consequences and have significant impact on the public, personnel, environment or physical plant. Major hazards are usually caused by breach of containment which may result in fire, explosion or toxic release . Hazards with lesser consequences are included at this stage if a relatively high frequency of occurrence is expected.

The analysis involves a systematic review of the process design, ideally at the preliminary Process Flow Diagram stage of Development Hazards associated with each major equipment item are brainstormed and tabulated under heading suech as "hazard", "cause", "effect", safeguards", recommendations", and "priority rank". Safeguards and recommendations are included only if they are readily identifiable at the time of review. The priority rank is taken from a hazard screening matrix that takes into consideration the severity of the hazard as well as the probability or frequency of occurrence.

The ranked list of hazards is used to prioritize and steer further design development, including the identification of safety systems required and the level of integrity required for these safety systems.

This task generally will require the assistance of safety, fire protection, and environmental specialists as well as representatives from project Engineering, Control Systems and Plant Operations.

2.5 Studies and Optimization

In this stage various processing methods and alternate operating parameters are examined in order to arrive at the most economics process plant design. Examples of typical studies and optimization topic are,

- Optimizing product recovery.
- Evaluating heat integration options including optimizing approach temperatures in a heat exchanger train.
- Evaluating air cooling versus water cooling.
- Optimizing reflux rate versus number of trays in a column.
- Selecting the most economical reboiler circulating and control scheme.
- Studying the effect of operating conditions on catalyst life and/or turndown frequency.
- Evaluating alternate light ends separation sequences.

Promising design enhancements are then evaluated against the project criteria for safety, reliability and economics.

2.6 Preliminary Equipment List

The preparation of a preliminary equipment list at the start of project will facilitate planning, order-of magnitude cost estimating and preliminary scoping of activities for all disciplines.

Process Engineering will generally prepare the preliminary equipment list if one has not been supplied by the client or licensor. As an aid in preparing this list, the equipment, unless more detailed information is available at the start of the job.

2.7 Heat and Material Balance

The heat and material balance defines the sequence, conditions and quantities of chemical and physical changes and transfers required to manufacture products from raw materials in the plant.

Steady state chemical processes must be simultaneously balanced in both material and energy. In most cases, heat and material balance circulations are performed (or verified) using process simulation software. The simulator output printout can be formatted to provide tabulated data that can be transcribed directly to the PFDs or issued as an addendum to the PFDs. The heat and material balance forms the basis for development of stream property tables and equipment data sheets.

Two major concern with regards to heat balances involve the proper accounting for heat of chemical reaction/solution and for process heat losses/gains. The heat of chemical reactions must always be included in the design of any reactor system.

Stream flows must always balance by mass. They must also balance by molar flow, allowing for any reactions that occur, but may not necessarily balance by volumetric when changes in temperature, pressure and/or chemical conversion occur.

2.8 Process Hazard Analysis

The process Hazard Analysis (ProHA) is an ad hoc, ongoing activity interlaced among all the other activities of Phase-II Design Development. The Process Engineer should periodically pause the process design activities to conduct a ProHA on identifiable segments or sub-systems of the process.

The purpose of a ProHA is to systematically examine the process design to identify potential hazard and assess their severity and likelihood of occurrence. The Preliminary Hazard Analysis (PreHA) report can be used as a checklist to see if previously identified issues have been addressed. "What If" and "Fault Tree" analysis can be used to uncover other potential hazardous situations. The ProHA should confirm that steps taken to mitigate hazards identified in the PreHA have not been compromised by subsequent design work and also confirm that these steps have not introduced new hazards.

Depending on the specific project, ProHA issues that might be considered include spill scenarios, gas dispersion modelling for combustible or toxic releases, reliability of metallurgy and other materials, components failure rates, operator responses and error, fail-safe instrumentation, equipment spacing, philosophy, thermal runway and associated vent sizing, detonations and resulting shock waves etc.

2.9 Process Description

The process description is a detailed explanation of how the process operates that is a narrative of the process flow diagrams. It is generally used as the basis for preparing the operating manual for the plant. However, an early draft can be useful in orienting project personnel as they are added to the project team.

2.10 Discipline Design Review

Following the preparation of the Process Description and the issue of the IFA PFDs, a review discussion is held to orient downstream engineering disciplines (and representative of the Procurement and Construction organizations, if possible) and advise them of special process design considerations. Feedback from the disciplines should be solicited with the objective of ensuring that proposed equipment and control schemes are appropriate, practical, safe and economic. Documentation of the review session should highlight special studies and/or mechanical requirements or limitations that need to be addressed.

2.11 Waste Minimization Assessment

Using preliminary PFDs or process sketches for reference, Process Engineering will evaluate waste minimization opportunities. Environmental input may be required to identify the pertinent regulations and potential future liabilities associated with generation of waste streams. Alternate design approaches that redudce or eliminate the production of non-product should be considered. Feasibility and economics of each process design alternate should be evaluated. The relevant PSHES and PreHA issues and recommendations should be reviewed as part of the activity.

2.12 Process Flow Diagram

The Process Flow Diagram (PFD) is the single most important documentation of the process design. PFDs can be developed once the conceptual design and studies are

near completion. A complete PFD will show a heat and material balance, stream properties, equipment data, operating conditions and major control requirements.
For all projects, at least two formal issues are made: issue for approval(IFA), issue for design(IFD). Preliminary informal issues may be made pre-IFA to help progress the conceptual work. The IFA issue is used to solicit client comments on the conceptual design and studies prior to detailed design execution. An IFA PFD review session should be held followed by client sign-off before proceeding with further design. It is important to involve the client in all major design decisions so that there are no surprises at the IFA review.

The IFA PFD is also the key document for initiation of P&ID's material selection guides (MSG) diagrams, and major equipment design pressure/design temperature (DPT) diagrams. However, because the MSG and DPT diagrams are typically issued as overlays of PFDs, the first formal issue of these documents should be based on and consistent with the IFD PFD.

The IFD PFD issue incorporates client and other review comments subsequent to the IFA issue incorporates client and other review comments subsequent to the IFA issue. The IFD PFD is supported by and shold be consistent with process equipment data, stream properties, utility summaries etc. that are used for detailed engineering design. The PFD should be revised and reissued as needed(Re-IFD etc.) to incorporate subsequent design development, feedback from mechanical design and other review activities.

3. PHASE III : PREPARATION OF INPUTS FOR OTHER DISCIPLINES AND ALSO FOR DETAILED ENGINEERING

The details of responsibilities associated with preparation of inputs for other disciplines and also for detailed engineering are described in the work process/procedure.

Work Process/Procedure,

This work process/procedure describes the basic engineering activities which are to be taken up in continuation with the activities as described under "Design Development" (Phase II) phases as described in the document.

This preparation of inputs for other disciplines and also for detailed engineering design development guide contains,

(a) a narrative describing each of the Process Engineering Design Development activities,

(b) a block flow diagram **(Attachment 5)** indicating the work flow logic, the approximate sequence of the activities, and their relationship to key project interfaces and milestones, and

(c) a work flow matrix **(Attachment 6)** identifying the flow of information to and from Process Engineering suppliers and customers.

3.1 Electrical Area Classification Input

Process Engineering will advise the Electrical group of potentially hazardous substances used to produced in the plant which may impact the electrical area classification. In most cases this will involve preparing an annotated equipment list categorizing each service with respect to the composition and key properties of the process streams.

Key properties include the flammability limits, auto ignition temperatures, and the partial pressure of heavier than air gases. This information is used by the Electrical group to prepare the electrical area classification drawing overlay of the plot plan. Process should review the area classification drawing prior to issue.

3.2 Material Selection Input

The Material group is responsible for producing the Material Selecting Guide (MSG)

Diagrams which specify the equipment and piping metallurgy and corrosion allowances.

To support this activity, Process Engineering should identify all known process conditions and variable affecting the material of construction. The process engineer must be careful to not maximum and minimum operating conditions rather than normal, and to define all trace quantities of known corrosion-inducing materials.

The metallurgical engineer is then responsible for translating this information to specify the material of construction and corrosion allowances for each equipment item and piping. This information is documented as an overlay to service classification (e.g., lethal service, sour service, wet H_2S service etc.) and which equipment and piping is to be post-weld heat-treated.

Depending on the specific needs of the project, a Material Selection Report is issued instead of Material Selecting Guide (MSG). This document addresses the same information and Process responsibility for the support of this document is identical.

3.3 Stream Property Tables

Process stream flows and properties are required for detailed process engineering activities such as line sizing, line list preparation, control valve sizing and instrument specification.

To meet these needs, stream property tables are prepared cataloging extrinsic properties (e.g. temperature, pressure) and intrinsic properties(e.g., specific gravity, viscosity) for process streams. The tables are keyed to the stream number of the PFDs.

Supplementary charts or diagrams may be prepared as necessary to show how a process stream's properties such as specific gravity or viscosity, change with temperature.

3.4 Equipment Datasheets

A process datasheet is prepared for each equipment item. The datasheet shows the operating conditions and defines the process duty for that equipment item.

Normally, Process Licensor supplies datasheet for vessels (reactors, column, drums, tanks), heat exchangers, fired heaters, compressors, pumps and special equipment and packages. In such case the first issue of a process datasheet should be IFD and should be consistent with the information shown on the licensor PFD.

Datasheets are prepared using standard formats. Process Design Guides dictate the completeness of data that must be provided on these datasheets so that downstream engineering disciplines have sufficient information to begin mechanical design.

3.5 Control Narrative

If required, a description of the process control concepts and logic for operation, start-up and shutdown is prepared and is provided as a deliverable in the Process Package. A control narrative is typically required when the design involves complex or unusual control schemes that cannot be completely described by the PFD symbology alone. The control narrative may be developed in cooperation with Control Systems engineers.

Process Control Diagram(PCDs) may also be used to supplement the PFD and the Control Narrative. PCDs are not P&IDs, but do show critical control instrumentationin more detail than a PFD.

Sometimes a PCD is required to explain the control of a batch, semibatch or cyclic process where a separate drawing can show more details than the PFD. For example, in this case of a multi-column molecular sieve adsorption unit, one column may be adsorbing, a second column regenerating and a third column cooling and stand by. The complex piping, valving and control instrumentation can all be shown on this supplementary diagram without cluttering the PFD.

3.6 Emission and Effluent data

Process environmental considerations ae reviewed and emission and effluent data are estimated for use in environmental reports. All waste streams must be qualified and characterized and enough data provided to support any permit application requirements.

3.7 Catalyst and Chemical Summary

A list of all chemical reagents, additives and catalyst required to start-up and operates the plant will be prepared. The list should include both discrete and continuous demands pertaining to initial fill and operating requirements. The anticipated rate of consumption, storage requirements and method and form of delivery to the site should also be included. Inputs from the Process Licensor are essential for preparing this document.

3.8 Plot Plan Input

Process contributes to the conceptual basis for preliminary plot plan studies by the Plant Design and Piping group. Project schedule considerations may stipulate that this input be based on very preliminary process design information. For example, the initial PFD issues and the data sheets for major process equipment.

The process focus should be on operational, access and safety issues with particular emphasis on two-phase flow, continuous drainage, equipment isolation, inventory minimization and anticipated requirements for relief system facilities.

3.9 Major equipment design temperature and pressure input

After development of the PFDs and definition of alternate design conditions, the Process Engineer can set design pressures and temperatures for major equipment.

Equipment design temperature and design pressure should be set to accommodate normal operating conditions, alternate operating conditions and upset conditions without compromising the integrity of the system.

To facilitate the overall analysis, design temperature and pressure should be developed and documented as an overlay of the IFA PFD with the final issue consistent with the IFD PFD issue. Design pressure and temperatures should be established with enough conservatism to minimize subsequent changes.

Detailed Engineering then assumes responsibility for this document and any subsequent changes that are made as detailed design development continues.

3.10 Process safety Review

A Process Safety Review (PSR) should be conducted just prior to the IFD PFD issue. The purpose of the PSR is to ensure that all safety issues have been adequately addressed. This review should be an independent safety audit let by an off-project Lead Process Engineer(LPE) not directly involve in process design.

Depending on size and complexity of the process, an individual process engineer may conduct the review alone or with the assistance of a review team comprised of other off-project specialist and on-project personnel. The on-project LPE is responsible for providing all information required to conduct the review and to arrange for additional inputs from specialist if warranted.

The scope of the PSR audit will cover the PSHES and PreHA reports and any other process studies or hazard analyses completed up to this point including, simulations, gas dispersion models, heat radiation studies, relief system design philosophies and overpressure calculations.

Reference documents should include the latest available PFDs, P&IDs, plot plan and equipment arrangement drawings and process control logic diagrams or narratives. The process engineer documents the audit findings in a PSR report highlighting any issues that have not yet been resolved.

3.11 Utility Summary

The utility summary is a tabulation of utility consumption and/or production by major equipment item for each utility commodity. Design and maximum rates as well as any other identified intermittent deviations from the normal rate should be delineated.

The utility summary should be based on and be consistent with the PFD, heat and material balance, stream property requirements and cover all major design cases.

Note that the Utility Summary only identifies process utility requirements. This summary will be expanded during detailed engineering with other additional utility loads (e.g., utilities required for turbines, compressor auxiliaries, steam tracing, lighting etc.) to create a detailed and complete utility balance.

3.12 Process Package

The front-end engineering design deliverables are documented and issued as a Process Package. This document essentially an assembly of previously issued information, but is issued as a package to provide a benchmark reference for future detailed design work.

At a minS0imum, the package should include;

- Process design basis
- Alternate design conditions
- Process flow diagram(IFD)
- Heat and material balance
- Stream properties data
- Process description
- Control narrative
- Equipment data sheets(IFD)
- Material selection guide
- Utility summary
- Catalyst and chemical summary
- Emission data
- Material safety data sheets(MSDS)
- Process safety Management (including PSHER, PreHA, ProHA and PSR)

4 .PHASE IV : DETAILED DESIGN

The details of responsibilities associated with detailed design phase are described in the work process/procedure.

Work Process/Procedure,

This work process/procedure describes the detailed design activities which are to be taken up in continuation with the activities described under basis engineering phase Phase-III namely by other disciplines, preparation of inputs fot other disciplines and also for detailed engineering.

Detailed design development guide contains,

(a) a narrative describing each of the Detailed design activity.

(b) a block flow diagram **(Attachment 7)** indicating the work flow logic, the approximate sequence of the activities, and their relationship to key project interfaces and milestones, and

(c) a work flow matrix **(attachment 8)** identifying the flow of information to and from Process Engineering suppliers and customers.

4.1 Hydraulic Calculation & Line Sizing

Process should review/perform compressor, pump and control valve hydraulic calculations performed by licensor (in case basic engineering is obtained from the licensor) to ensure correct interpretation of process data, concepts and expected range of operation.

4.2 **Relief System Design**

Process will issue a design specification for the relief system that will document the overpressure protection philosophy and flare system design basis. This design package will include the following items;

- A statement of the basis assumptions and design standards that have been applied to the design.

- Relief load data sheets for each relief valve and/or rupture disk service. The datasheet summarizes the relief load and conditions associated with each relief case.
- Aggregation of relief loads into area-wide relief contingencies such as plant utility failure or fire.
- Characterization and quantification of non-relief loads such as continuous process vents.
- An onsite relief system process flow diagram. This PFD is typically drawn as a pilot plan overlay or at least arranged in relative geographic layout. The controlling case for each relief source should be tabulated at the bottom of the drawing. The PFD should also indicate the preliminary size and sizing basis for headers and sub headers. The flare header liquid drainage philosophy and the required flare knock out facilities should be shown. Header purge gas requirements(flow and velocity)should be specified.
- An offsite flare system process flow diagram. This PFD shows the type and size of the flare as well as related equipment such as knock-out drums, seals etc. A separate plot plan Overlay should be prepared to illustrate the location of flare with associated radiation and vapor dispersion profile curves. The requirements for smokeless operation should be addressed.
- Process data sheet for flare related equipment including knock-out Drums, knock liquid pumps and coolers and the flare stack.

  Note : This is a conventional approach. However whenever a software like FLARENET is used for Flare analysis and sizing of flare header/subheaders, such kind of a flow diagram is an integral part of FLARENET output and hence it need not be prepared separately.

4.3 Preparation of P&IDs, (Process, Auxiliary & Utility P&IDs)

In this phase, the P&ID begins to substitute for the PFD as the primary control document of the project. Therefore it is most important that Process participate in all the P&ID reviews. The Process role is to verify that the design specifications as stated on the PFDs, equipment data sheets and other Process document has been properly translated to the P&IDs. Process also assumes an overall role to assure that all design objectives are met by the design as depicted in the P&ID. Process should be vigilant about critical issues like two-phase flow problems, flow distribution problems and continuous drainage requirements.

4.4 Preparation of line list

The Line Lists are prepared/reviewed by Process to ensure that data from the Stream Property Tables has been correctly applied. Process also checks that all contingencies mentioned in Alternate Design Conditions above have been satisfied. If insulation, tracing or winterizing is required for Process reasons, this should be also designated on the Line Lists.

4.5 Preparation of Cause & Effect Diagram

P&ID Diagram depicts simple as well as complex control loops & interlocks. However it may not be possible to communicate for interdependence of parameters for various trip logics on P&IDs. To facilitate such explanations to control engineers (who ultimately build a trip logic in PLCs); a cause and effect diagram prepared by Process Engineer.

4.6 Hazard and Operability Review

A structured, formalized Hazard and Operability (HAZOP) review will be conducted by a team consisting of a Process Engineer familiar with the process, Safety Specialist, Control Systems Engineer, Project Engineer, Material group and other specialists and disciplines as needed.

The HAZOP review is a systematic technique for identifying hazards and operability that might exist in the process plant. The purpose of the HAZOP is to uncover and documents potential hazards and operability problems.

The HAZOP review methodology involves dividing the process into nodes(small, logical partitions of the process) and then applying a series of guide words (such as high pressure, low pressure, high temperature etc.) to each node.

For each permutation of nodes and guideword, possible causes and consequences are listed. An evaluation is made of the adequacy of the currently specified safeguards. Recommendations may be made for further study or specific design action.

The HAZOP review is documented in a report including the P&IDs marked up to show the nodes that were studied and copies of the worksheets recording the discussion and consensus reached at each node/guideword. The report lists the action items and assigns follow-up responsibility.

Note that it is not the purpose of the HAZOP to develop solutions to the problems identified in the process. Potential solutions may be suggested or recommended but the ultimate resolution of any issues is deferred as an action item to be addressed outside of the HAZOP review.

4.7 Special Design Studies

Depending on the specific project requirements, additional process design studies may be necessary during the detailed design phase. This type of work would typically be focused on technical and cost comparisons of alternate design options.

Additionally Process should review critical hydraulic designs such as multiphase flow and flow distribution manifolds.

4.8 Preparation of Battery Limit Connection Schedule

At this stage a single BLCS document is prepared & updated by process which contains Battery Limit integration of the Process unit. This document can then be used for design & integration of Offsite & Utilities facilities.

4.9 Updation of Equipment list

The preliminary equipment list which is prepared during the design development phase-II is updated as more & more information is available to the process. After this time, the process engineer submits process equipment changes to the project engineer for the updation / revision of official project list.

The Preliminary Equipment List also serves as the guide for the preparation of Equipment Data Sheets. If a piece of equipment appears on the Process Engineer's Preliminary Equipment List, a data sheet should be planned for that terms.

4.10 Review Material Requisitions

Process Engineering reviews Material Requisitions(MRs) at the Issue for Quote (IFQ) stage to ensure correct interpretation of process requirements. IFQ review is particularly important when proprietary information or design along with performance guarantee is being sought from vendors. However this is done only when there is a specific request by Mechanical/Project department and not as a standard practice.

Issue for Purchase(IFP) review may be necessary to confirm that selected equipments meets the original need. In some cases, alternate design may be selected as a more cost effective option.

Process may need to review equipment specifications from licensors and vendors who hold rights to processes and equipment design. Licensor and vendors may contribute significantly to process design activities. They are often utilized to provide project or study inputs such as,

- Process know-how through brochures and publications
- Process design information
- Reactor design / any critical equipment design conditions
- Complete equipment design

5. PHASE V : PROJECT SUPPORT

The details of responsibilities associated with Project Support phase are described in the work process/procedure.

Work Process/Procedure,

This work process/procedure describes the detailed design activity namely project support which are to be taken up in continuation with activities described under detailed engineering activity. This guide contains;.

(a) A narrative describing each of the project support activity.

(b) A block flow diagram **(Attachment 9)** indicating the work flow logic, the approximate sequence of activities and their relationship to key project interfaces and milestones, and

(c) A work flow matrix **(Attachment 10)** identifying the flow of information to and from Process Engineering suppliers and customers.

5.1 Hazop Follow-Up Support

After the HAZOP review is completed and the report is issued, a formal program for resolution of action items and other concerns is established. Typically, a HAZOP will generate a list of items that need to be investigated before a decision on required action can be accomplished. Project Engineering is responsible for both co-ordination and documentation of the follow-up items and Process Engineering is generally a major participant in this effort.

5.2 Equipment Design Support

As detailed engineering for equipment progresses, some support from Process will be required to assist other disciplines in resolving areas of conflict or clarification. Examples of this may be: interference between tray internals and support steel, location of instrument connections/ thermowells related to platform access and process requirement, or hydraulics and pipe layout clarification based on stress data. When mechanical layout/design drawings are developed, Process should ensure that these documents are consistent with process data.

5.3 Equipment Design Support

5.3.1 Process engineers may after assistance to piping/project eng. To identify the equipment /loops in steam circuit which fall under statutory authorization. Any brief write-up if required regarding application may be prepared by process engineer so that mechanical/ project engineer will be able to prepare IBR Package which in turn will be submitted to IBR authorities for approval.

5.3.2 Special parts

Normally some specialty items(Like steam traps, strainers, flame arresters, etc) shall be specified and procured by PIPING discipline. However specification fot these items requires certain definitive process input. Process engineer shall furnish these inputs to piping dept in the form of specialty item datasheet.

5.3.3 Model Review

Piping shall be preparing 3-D model based on P&ID's released for design. However before construction drawings are extracted from this model- process engineer shall ensure that all process requirement(typical example are seal height, elevation of vessels, requirements of slopes as identified on P&ID, etc.) are taken care of. This shall be done by carrying outline by line check on the model at various stages (30%, 50% & 90%)of completion of 3-D model.

5.4 Vendor Print Review

Selected vendor prints will be reviewed to verify that process requirements have beed adequately met for key requirements have been adequately met for key equipments items. For example, it is important to review tower internals to ensure that vendor design, mechanical design and process design are consistent with regard to dimension layout, orientation etc.

5.5 Instrument Data Review

The Control Systems group will issue a data sheet for every instrument purchased on a project. Process Design should review this data to ensure that process design data utilized is accurate and appropriate set points or ranges have been selected. In most cases the Control Systems group will request pre-alarm, alarm, shutdown and set point confirmation from Process Engineering.

5.6 Complex Loop/Logic Narrative Review

A Complex Loop and/or Logic Narrative design package will be issued on every project by the Control Systems group. Process should review this data, and approve where required, to ensure consistency with the design concepts.

5.7 Process Audit

An audit is made by an off-project senior process engineer to critique the project execution and assess:

- Quality of process work
- Project execution strengths
- Project execution weakness
- Possible improvements to standard execution methodology

5.8 General Project Support

Following completion of the detailed process design effort, it is necessary to follow-up on all project work which could impact process equipment specifications or plant operations. In addition to reviews of P&IDs models, plot plans etc., follow-up includes working with downstream design disciplines to answer process-related questions and interpreting the process objectives to facilitate their work.

5.9 Monitoring identification, Control & Reporting of Changes

After HAZOP studies, necessary Hazop recommendations are incorporated and P&ID are released for design. Subsequently to this, P&IDs (and related documents liked LDT's, cause & effect, etc.) are released for construction when all the HOLD's w.r.t. vendor information, special part info., etc.) are removed.

Hazop closure items that are to be closed by other discipline like piping, mechanical, etc. needs to be followed up after Hazop and get them closed before IFC issue of P&ID's.

By large, no of fundamental changes are expected on the P&ID's (and associated documents) after those are released for design after incorporation of Hazop recommendation. However for various reason (like client recommendations, site constraints, vendor inputs, integration issues etc.)modification & changes to design do occur even after design are frozen(i.e., post IFD issue of P&ID's).

Therefore it becomes necessary to have a mechanism in place which maintains a record of post IFD changes in P&ID's (and related documents) with an emphasis on clearly identifying detailed reasons behind these changes. This system will consist of preparing a record of every such changes and each such record will cover the following.

i) Technical basis for changes
ii) Impact of the changes of safety and health of personnel & process
iii) Requirement of Re-Hazop
iv) Process safety methodology adopted to analyze the changes.
v) Authorization of change.
vi) Recommendation to Project Group for additional claims for manhours as applicable.

This helps a process engineer in,

i) Informing the changes to disciplines, about the impact even though revised document are released at a later stage and minimizing impact on procurement / construction because of change.

ii) Assessment of impact on safety because of change.

iii) Estimation of extra claims because of changes.

iv) Maintaining authentic records of all the post design changes.

6. PHASE VI : CLOSE OUT

The details of responsibilities associated with Close-out phase are described in the work process/procedure.

Work Process/Procedure,

This work process/procedure describes the detailed engg. activities which are to be taken in continuation with the activities under design project support phase.

This guide contains;

(a) a narrative describing the Close-out activities.

(b) a block flow diagram **(Attachment 11)** indicating the work flow logic, the approximate sequence of the activities and their relationship to key project interfaces and milestones, and

(c) a work flow matrix **(Attachment 12)** identifying the flow of information to and from Process Engineering suppliers and customers.

6.1 Process Close-Out Documentation

Properly constructed files and documentation are a valuable resource in follow-up work on a project. Such files represents one of the most important assets that an engineering company can accumulate. In order for a technical file to be effective. Considerable planning is needed to ensure that only vital information is preserved and that the organization and indexing ae adequate to facilitate quick retrieval of desired data.

In setting up Process files on a project, the lead process engineer is responsible for organization and indexing the following;

- Correspondence files

- Conference notes
- Subject files
- Major reports
- Process design package
- Other process deliverables
- Calculation files

In the Process Close-Out phase, the correspondence files, conference notes and subject files are to be preserved and placed in the custody of the lead process engineer. They should be maintained for ready reference for at least a year after close-out. If need for reference appears minimal, they may then be assigned to dead storage.

Major reports, process design packages, other significant process deliverables, and the process calculation files will be preserved in central Process Department files. As part of the close-out effort on a project, the lead process engineer is responsible for assembling these files in a prescribed format & transmitting them to the Department Manager.

6.2 Construction Support

Process support for construction may be requested when changes must be made in the field that may impact the process design. Some typical requests are

- Define impact of a line being raised, lowered or rerouted.
- Define construction that can be done prior to shutdown.
- Define the best sequence of tie-ins to minimize impact on an existing operation.
- Identify hydro-testing loops.
- Preparation of punch list at various stages of construction(viz. 70%, 90% & 100%) w.r.t. P&ID requirements.
- Modifying process documents like P&IDs w.r.t. clients requirements which may be received during construction stage.

6.3 Process Close-Out Documentation

When the list of contract deliverables includes an operating manual, the taskof coordinating the development of the operating manual as assigned to Process department necessary co-ordination with mechanical package units group. Commissioning group & clients (operation group)shall be done by process group only.

7. PHASE VII : START-UP AND COMMISSIONING ACTIVITIES

The details of responsibilities associated with Commissioning and start-up are described in the work process/procedure.

Work Process/Procedure,

This work process/procedure describes the engineering activities which are to be taken in continuation with the activities as described under "Close-Out" (Phase-VI) phase.

This guide contains;

(a) a narrative describing start-up & commissioning activities.
(b) a block flow diagram **(Attachment 13)** indicating the work flow logic, the approximate sequence of the activities and their relationship to key project interfaces and milestones, and
(c) a work flow matrix **(Attachment 14)** identifying the flow of information to and from Process Engineering suppliers and customers.

7.1 Commissioning Support

Process support of commissioning activities at the jobsite may include various activities. Some of the typical activities are listed below;

- Preparation of flushing loop diagrams.
- Preparation of punch list of the unit which involves checking of complete plant w.r.t. requirement of the P&ID. This involves typically,
    - Slope requirements

  - Line of start-up spools/lines
  - Correct position of blinds as per P&ID
  - Maintaining blind list and updating the same regularly.
  - Confirming installation of all instruments as per P&IDs
- Final punching of the unit when flushing of the line / equipments is completed and all the control valves/ orifices are fixed back. This involves checking direction of check valves etc. w.r.t. flow direction etc.
- Chemical cleaning of compressor suction lines
- Equipment dry-out, fixing on internals wherever applicable and subsequent inspection of equipments.
- Charging of adsorbents/catalyst/molecular sieves with corresponding supports etc. and keeping a record of the quantities charged as per the Licensor's recommendation.
- Assisting instrument engineers during stroke checking of control valves, loop testing, ESD logic testing and keeping record of the same.
- Low pressure/High pressure testing of the entire piping system with equipments inline with soap solution and hold.
- Assisting mechanical for no load and water run test of pumps as per licensors recommendations and certifying the same.
- Dry-out of the complete unit by firing the furnaces wherever applicable.
- Deoxygenating the system by vacuum pulling/N2 purging (as applicable) pressuring with inert material and readying the plant for "OIL IN".
- Checking underground system like closed blow down system and OWS.
- Commissioning of utilities like boilers, cooling water, plant and instrument air etc.

7.2 Pre-start up safety audit

Prior to start-up, a pre start-up safety audit should be conducted to ensure that all relevant issues concerning safety have been addressed. This audit is conducted after construction is complete and operating procedures have been prepared.

The pre-start-up safety audit should confirm;

1. Construction is in accordance with design specifications.
2. Safety, operating, maintenance and emergency procedures are in place and are adequate.
3. Process safety management issues identified during the project hane been addressed and all issues identified as necessary for start-up have been completed.
4. Adequate training of personnel in normal operating procedures and in upset condition/emergency response procedures has been completed.
5. HAZOP-if necessary for the major changes (if any) which might have been done at site.

It is essential that recommendations developed during the previous review procedures (PSHES, PreHA, HAZOP) be addressed prior to the safety audit. The resolution of these items is confirmed and documented in a pre-strart-up safety audit report. This activity may also include an inspection of the mechanical system to confirm installation of all equipment and devices recommended by prior safety reviews.

The audit also includes a review of the plant procedures. Because many of the recommendations developed during the previous safety reviews may involve operating, maintenance or emergency procedures, the written procedures must incorporate these recommendations. The audit should confirm that opeartors have been trained in these procedure.

7.3 Operator Training

Operator training is required for any project which involves installation of a new unit or modification of an existing plant. Training may either be handled by the client or it may be a contract deliverables.

If operator training is a contract deliverables, then it would be the responsibility of Process-primarily because of its general knowledge of the process and possible involvement in the preparation of the operating manual for the plant.

Operator training must stress the important of complying with established procedures to ensure safe operation and maintenance. The operators must also be made aware that prior to implementing any changes in the system or deviating from operating procedures, it needs to be reviewed for safety impact and ratified by a higher authority.

7.4 Start-up assistance

Process provides start-up technical service, if required by the client. This may primarily involve supplementing the client's own force, thereby ensuring the availability of all the technical help that may be needed during the start-up period.

Process participation in this activity is an excellent opportunity to collect feedback on the quantity of the design.

7.5 Participation in Guarantee Test Run

Process may also be requested to conduct Guarantee test runs (GTR). A GTR is required whenever certain process guarantees, such as product output, quality etc. have to be necessarily met.

A common problem in conducting such a test is that the design feedstock is not available. Agreement must be reached with the client on the plant performance to be expected with the actual feedstock.

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