Commissioning & Start Up Workshop
Day 1

Preparation

- Activities to set up Commissioning
- Gathering information
- Selecting the Commissioning Team
- Justifying the Schedule
- Creating Documentation

Learning Objective

By completing this module, you should understand the attributes of a Commissioning Manager, when he / she should be engaged, be able to describe their duties and responsibilities and define the type of chart used for this purpose.

Phase 1 - Preparation
Commissioning Manager

Key Attributes:

Highly skilled in Interface Management

Have intimate knowledge of the Plant / Facility

Know how each System will operate and be controlled

Role model to the Commissioning Team

Establish good relations with Safety and Operations

Phase 1 - Preparation

Commissioning Manager – responsibilities

For the scope in the Completions Pyramid:

Pre-Commissioning, Dynamic Commissioning, Startup

also, Normal Shutdown and Emergency Shutdown

Justifying, hiring, training and leading the Commissioning Team until Final Handover to Operations

Phase I - Preparation
Commissioning Team – responsibilities

Engage Stakeholders, define and make clear requirements for people, materials, equipment, access;

Participate in, and where needed, lead;

Systemization, Design reviews, HAZOP Studies, Management of Change (MOC), Pre Start Up Safety Reviews (PSSR), Factory Acceptance Testing (FAT);

Gap Analysis of systems, procedures and pertinent documentation;

Production of procedures from the Gap Analysis;

Evaluation and selection of the Systems Completions Database;

Justifying the Handover program with Operations;

Phase I - Preparation

Type of Commissioning Manager by Engagement

- Depending on the scope, the Commissioning Manager can be provided by Client or the Contractor;
- The Commissioning Manager representing either organization may operate as staff or consultant;
- For the Commissioning Manager engaged on a staff basis there will be different issues and concerns than if engaged as a consultant;

Phase I - Preparation

Type of Commissioning Manager by Engagement

Pros and Cons Matrix of Commissioning Manager from Operator or Contractor

Commissioning Manager	*Client / Operator*	*Contractor*
Staff	**Pros** • Should have sufficient authority • Will know the company and politics • Will focus on scope, not contract terms **Cons** • Experience levels • Availability	**Pros** • Greater focus on scope and contract • Experience levels **Cons** • Experience levels • May lack authority to get things done and hire Commissioning Team • Risk of being unable to fulfil usual Duties and Responsibilities • Scope may not extend through Start Up
Consultant	**Pros** • Wealth of expertise available • Not usually motivated by politics • Greater flexibility and adaptability • Focus on scope, not contract terms **Cons** • Authority levels insufficient • Insufficient company knowledge • Inability to leverage Stakeholders	**Pros** • Wealth of expertise available • Not usually motivated by politics • Greater flexibility and adaptability • Focus on scope, not contract terms **Cons** • May be engaged too late to be effective • May lack authority to get things done and hire Commissioning Team • Risk of being unable to fulfil usual Duties and Responsibilities • Scope may not extend through Start Up

Phase I - Preparation

Type of Commissioning Manager by Engagement

There are advantages and disadvantages to which organization supplies the Commissioning Manager, and staff or consultant basis. The recommendation is:

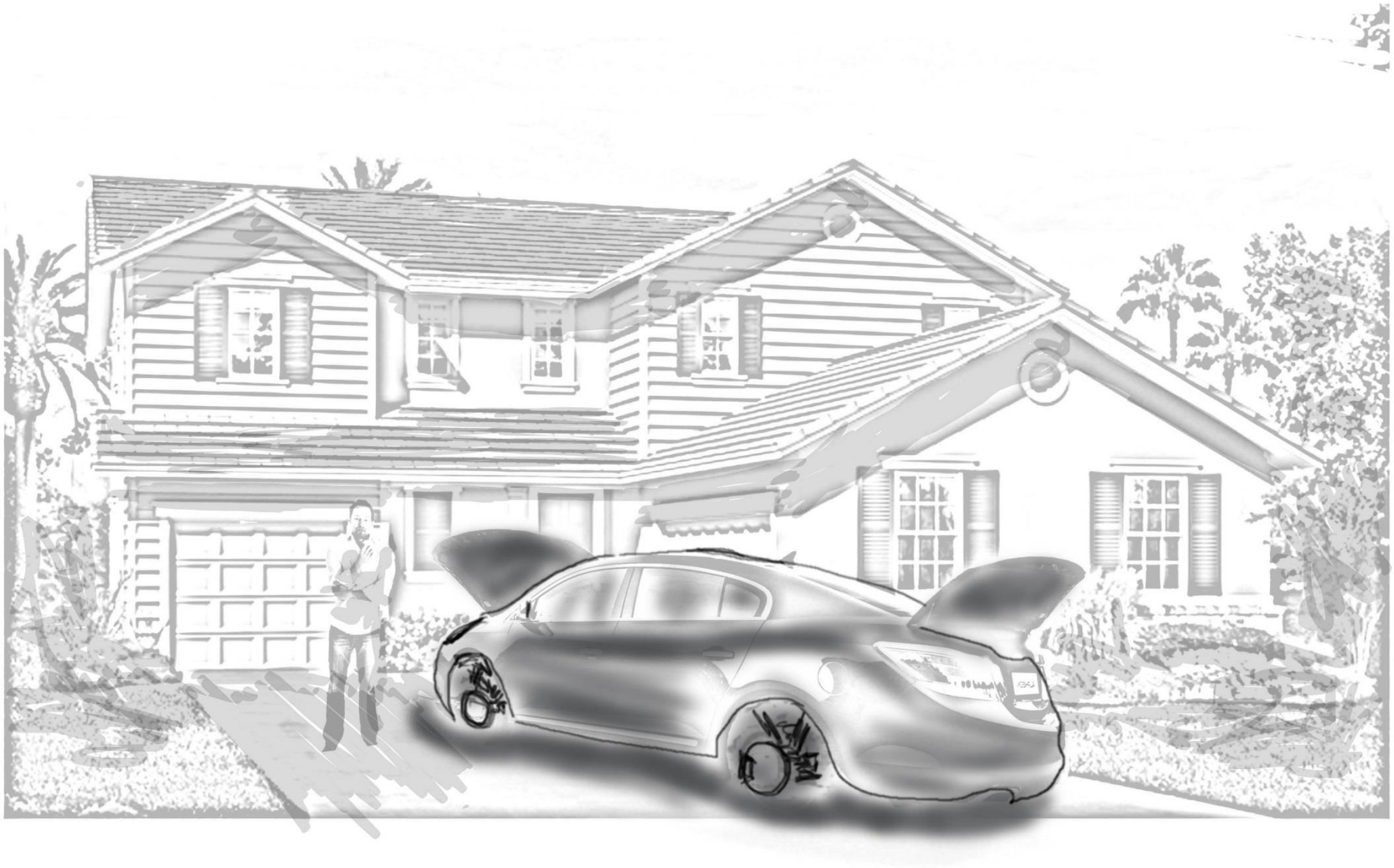
- Staff Commissioning Manager
- Consultant Deputy Manager / Lead Engineer
- Split Commissioning Team between Client and Contractor Teams as Completions Pyramid (slide 47)

Phase I - Preparation
The Elephant in the Room

The most effective single action any project can take is:

- Engage a Construction Manager with CSU experience
- Someone who was good at it!

The Problem with Mechanical Completion As currently defined



The Problem with Mechanical Completion

As currently defined

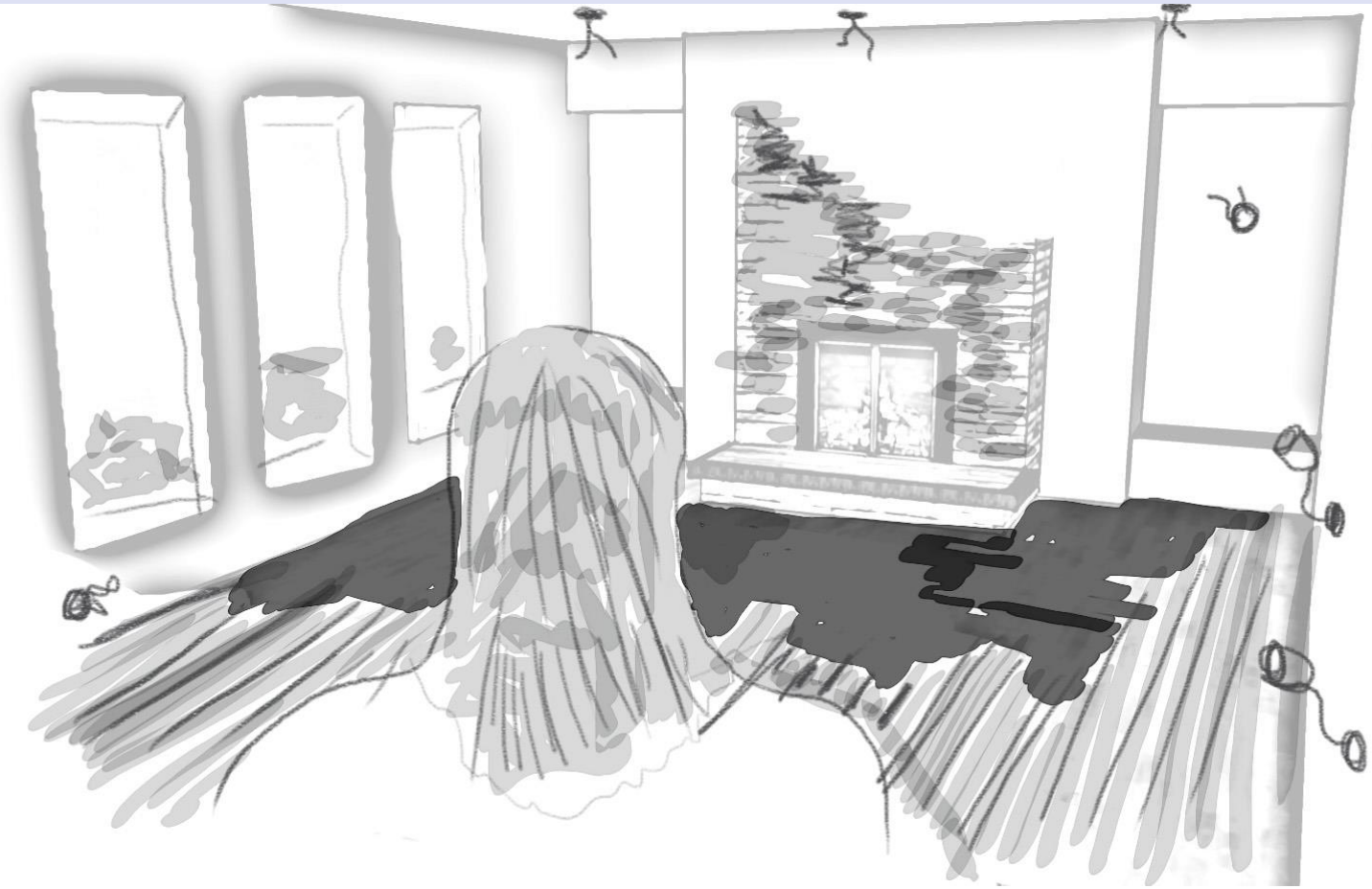
Phase 1 - Preparation

The Problem with Mechanical Completion

The Problem with Mechanical Completion

As currently defined

The Problem with Mechanical Completion

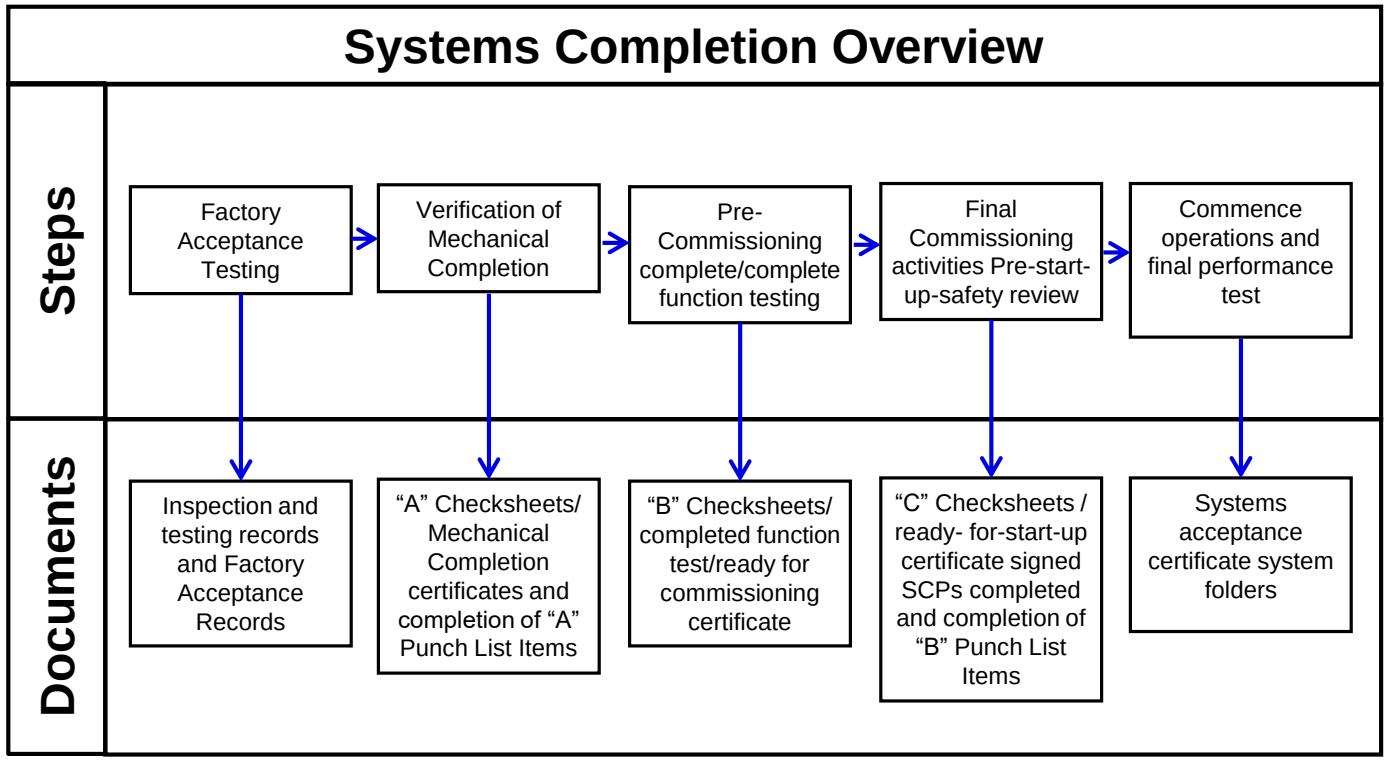


The Problem with Mechanical Completion

Commissioning & Start Up with API RP 1 FSC

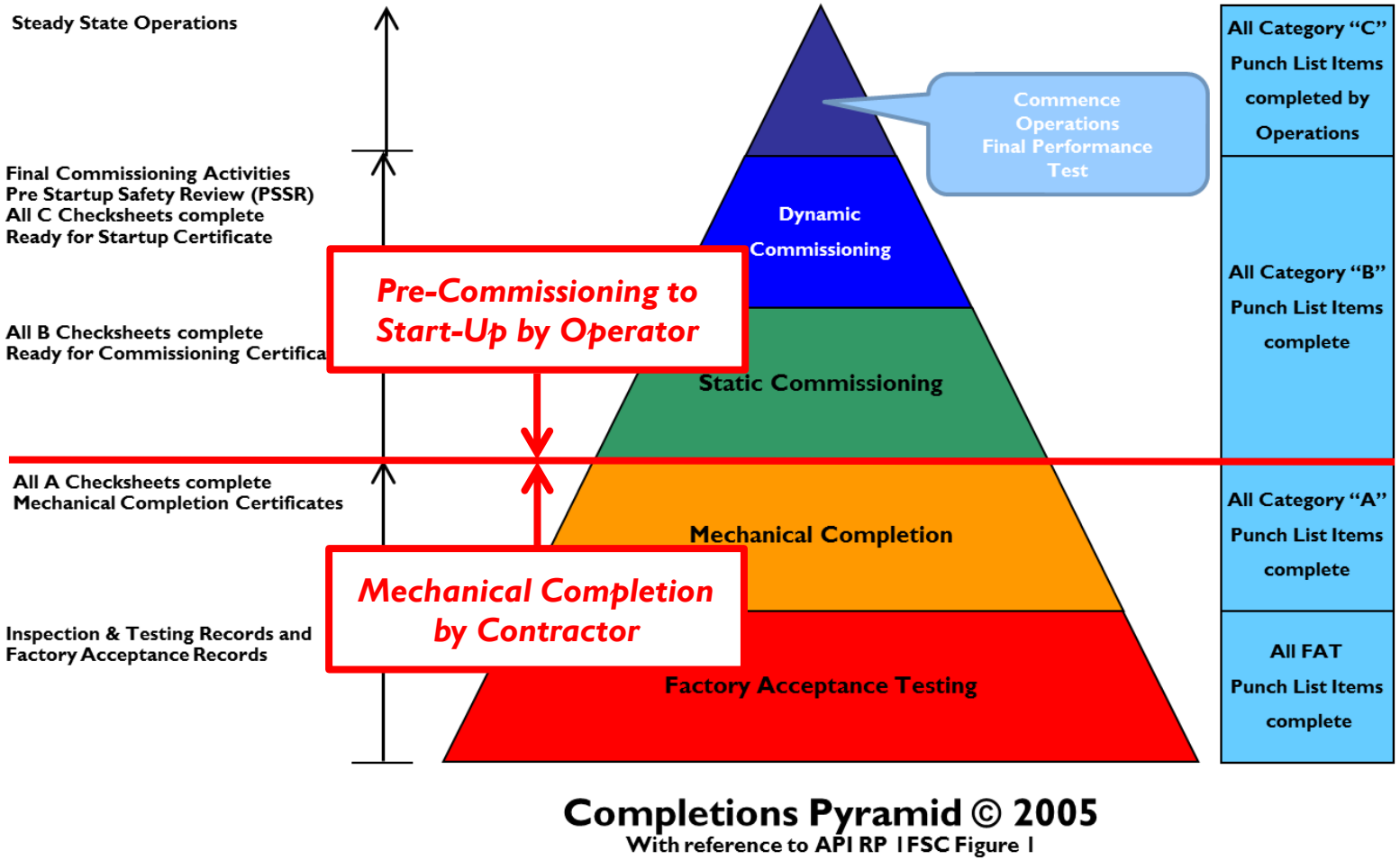
The Solution –
Redefine
Mechanical Completion
To Something Useful
Raise the Bar

Handover Assurance
Systems Completion Execution Process



API RP 1FSC Recommended Practice for Facilities Systems Completion Planning and Execution, 1st Edition – Courtesy of API

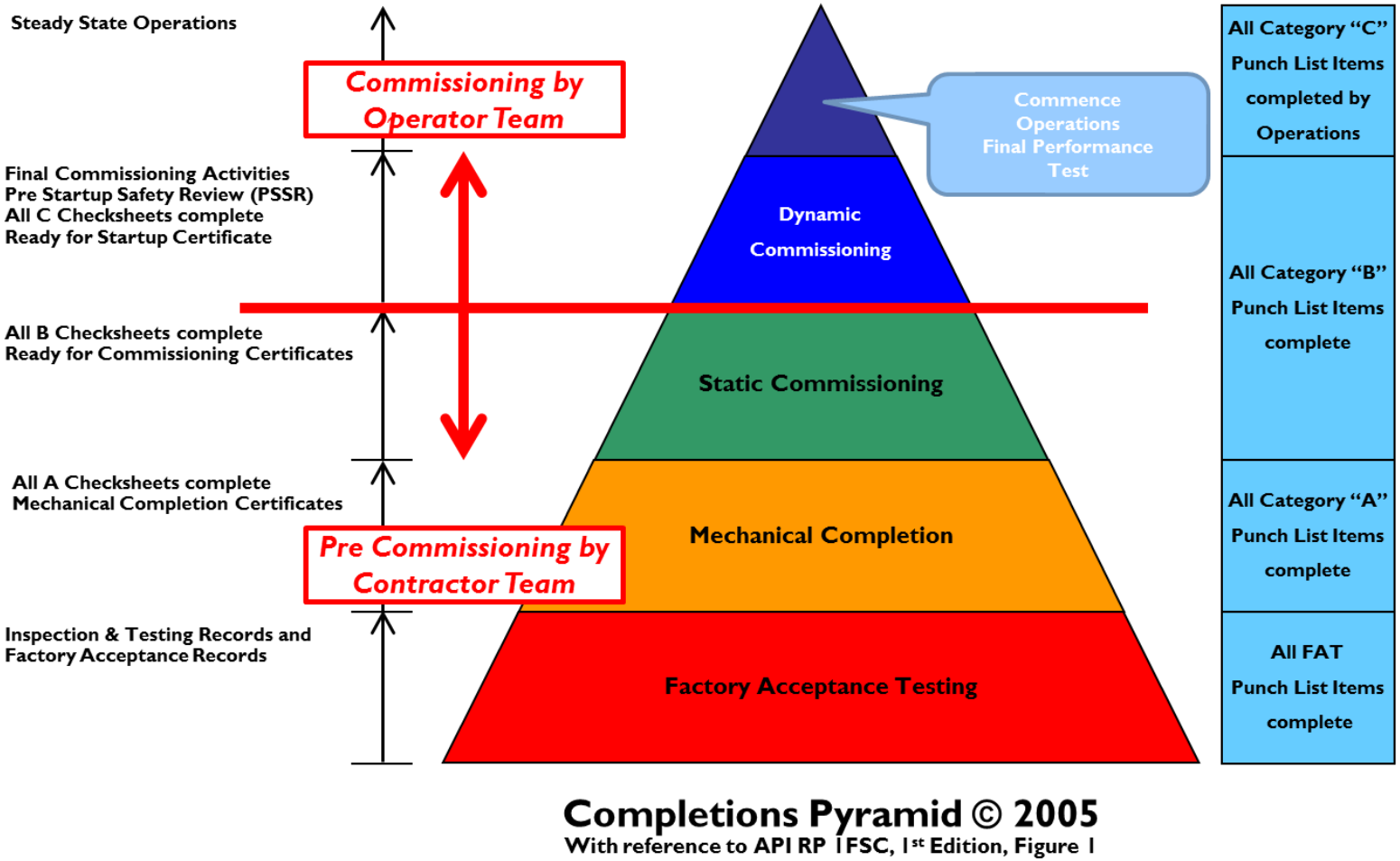
Current Reality
Contractor-Operator Commissioning Teams



Completions Pyramid © 2005
With reference to API RP 1FSC Figure 1

Raise the Bar 1

Contractor-Operator Commissioning Teams



Completions Pyramid © 2005

With reference to API RP 1FSC, 1st Edition, Figure 1

Note, only suitable for more capable Operators working with more technically advanced EPCs

Phase I - Preparation

Contractor Scope to Pre-Commissioning

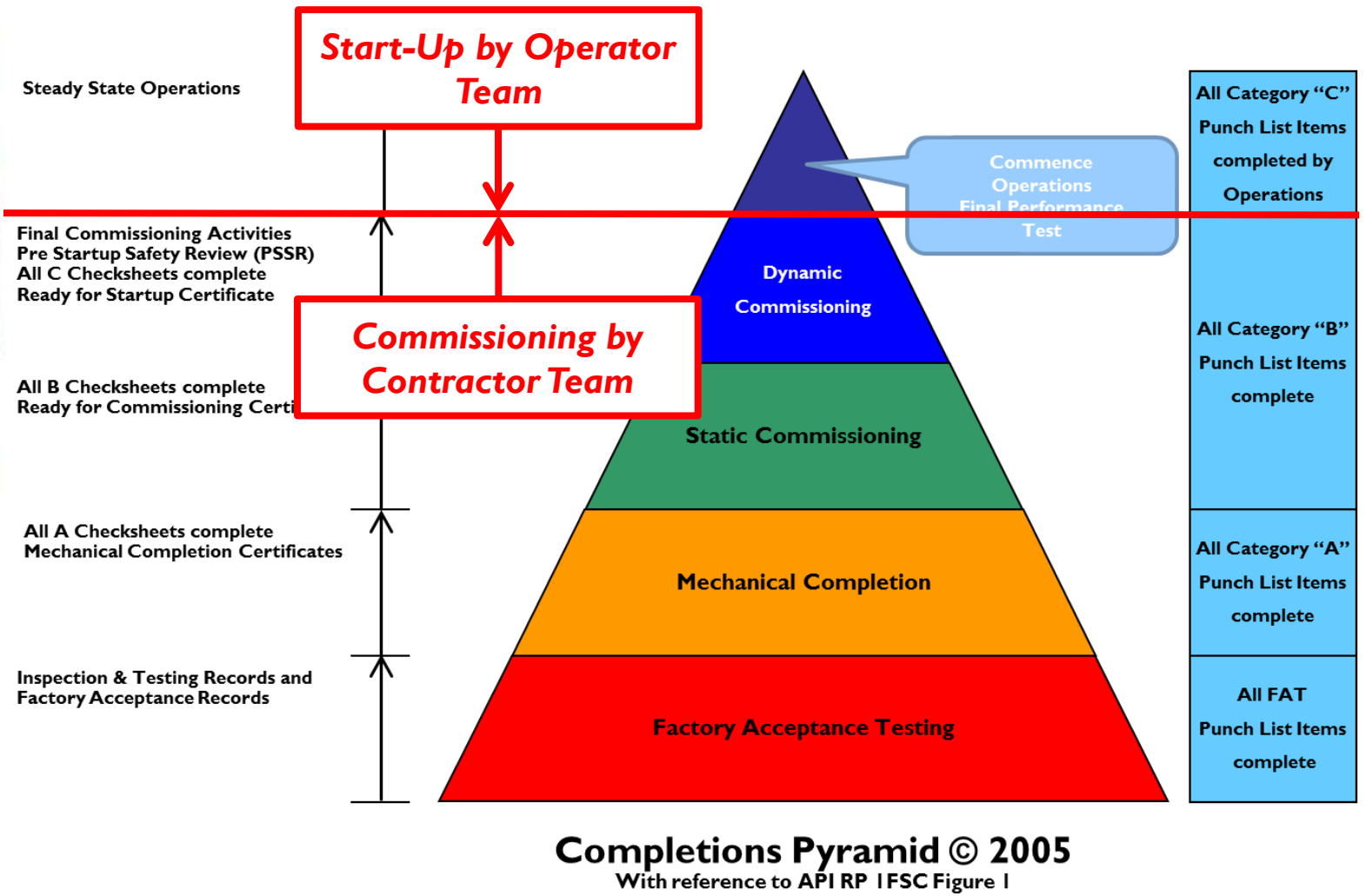
- All E ITRs & V ITRs through FAT
- Any outstanding PLIs from FATs
- A ITRs through Mechanical Completion and Cat A PLIs
- Discipline, Sub System and System MC Certificates
- B ITRs through Pre-Commissioning and Cat B PLIs
- Ready for Commissioning Certificate (RFCC)
- C ITRs, aka OTPs, aka Commissioning Procedures and Cat C PLIs

Phase I - Preparation

Contractor Assistance through Commissioning

- C ITRs, aka OTPs, aka Commissioning Procedures
- Leak Testing
- Chemical Cleaning
- Mechanical Cleaning
- Shutdown Tests

Raise the Bar 2
Contractor-Operator Commissioning Teams



Completions Pyramid © 2005
With reference to API RP 1FSC Figure 1

Note, only suitable for more capable Operators working with more technically advanced EPCs

Phase I - Preparation

Contractor Assistance through Commissioning

- Decide scope and demarcation early on
- Include in Contractor scope, if assistance is required
- Know battery limits and activities
- Develop RACI

Phase I - Preparation
Type of Commissioning Manager by Engagement

A Simplified Commissioning Logic with *Zenator Systems*

Step 1 – Preparation and Outline PlaNning
During Front End Engineering Design (FEED)

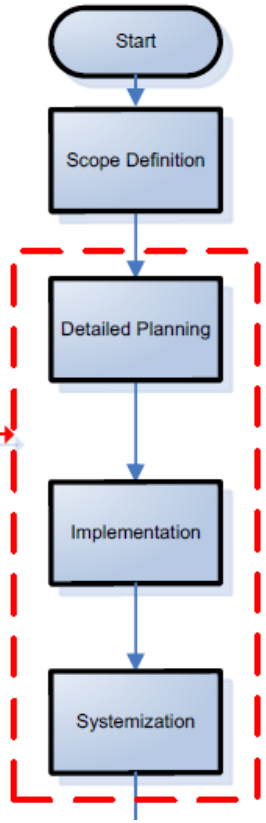
Step 2 – Detailed Planning
At Start of Detailed Design

Refer to API RP 1 FSC Tab 1, Systems Completion Planning and Organization Activities

Step 3 – Implementation
Within 3 months of Start of Detailed Design

Step 4 – Systemization
Within 6 months of Start of Detailed Design

Steps 5, 6 & 7 – Mobilize, Reporting, Work Flows
Within 9 months of Start of Detailed Design



- Establish Project Expectations and Requirements to define the work scope for Commissioning & Start Up
- Develop and outline Schedule to show timeline
- Develop a budget
- Recruit the Commissioning Manager and key team members
- Engage Stakeholders and build relationships

On budgetary approval, develop requirements for:

- Recruit and train the Commissioning Team
- Develop Procedures and Handovers
- Schedule participation in Vendor Inspections and FATs
- Perform Gap Analysis – Skill sets, Work Processes, Equipment, Documentation

- Engage Specialist Subcontractors
- Raise POs for Specialist Equipment
- Participate in Systemization, HAZOPs with Operations and Engineering
- Identify Checksheets and Tag Type Matrix
- Monitor Scope, Schedule & Budget, refine if needed
- Develop RACI, Work Processes for Commissioning
- Finalize Performance Testing criteria
- Plan mobilization to Site(s)

- With Operations and Engineering, set Battery Limits on P&IDs
- Agree Handovers with Construction and Operations
- Produce Documentation and Zenator Reports
- Start populating Zenator with Project Data

Help is at Hand

API RP 1 FSC
First Edition, July 2013
Facilities Systems Completion, Planning & Execution

Phase 1 - Preparation

API RP 1FSC, 1st Edition – Courtesy of API

Table 1—Systems Completion Planning and Organization Activities

Recommended FEED Planning Activities	Recommended Detailed Engineering Activities
a) Develop systems completion strategy.	a) Systems completion risk assessment.
b) Develop systems completion execution plan.	b) Finalize systems and sub-system definition and inclusion in engineering documents.
c) Define certification process.	c) Procure and implement SCDB.
d) Review asset register and ensure systems completion (SC) database requirements are included.	d) Obtain and track vendor IRN and punch lists in SCDB.
e) Produce system list and minimum system testing requirements and acceptance criteria.	e) Develop permit to work (PTW)/lockout/tag out (LOTO) system.
f) Produce initial start-up sequence with milestones and integrate into schedule.	f) Produce site SC turnover procedure: 1) define certification process; 2) define and prepare turnover completion package; 3) finalize SC milestones and schedule.
g) Identify risks based on start-up sequence.	g) Define and purchase commissioning and start-up spares.
h) Produce SC scope for execution contracts.	h) Witness and track factory acceptance tests.
i) Identify required function tests, tie-ins, commissioning, and/or start-up procedures for each system.	i) Review project redline procedure.
j) Identify and plan regulatory requirements.	j) Produce and finalize the following plans: 1) systems completion execution plan; 2) systems completion database execution plan; 3) equipment preservation plan; 4) vendor support plan; 5) subcontracts plan and SOW; 6) produce systems completion turnover package (one per system), see example in Annex A.
k) Provide and review SC requirements in procurement plans.	k) Finalize systems definition and mark on engineering documents.
l) Define A, B, and C check sheets and preservations responsibilities, requirements, and certificates.	l) Safety instrumented function proof test procedures.
m) Define inspection test plan with project quality process.	
n) Initiate systems definition on PFDs, P&IDs, instrument block diagrams, and one line diagrams.	
o) Gather lessons learned for inclusion into execution plan.	
p) Liaise with engineering to agree an efficient and controlled data exchange with SCDB.	

API RP 1 FSC

Deals well with Time, Money, People, Action

Table 1—Systems Completion Planning and Organization Activities

Recommended FEED Planning Activities	Recommended Detailed Engineering Activities
a) Develop systems completion strategy.	a) Systems completion risk assessment.
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m) Define inspection test plan with project quality process.	
n) Initiate systems definition on PFDs, P&IDs, instrument block diagrams, and one line diagrams.	
o) Gather lessons learned for inclusion into execution plan.	
p) Liaise with engineering to agree an efficient and controlled data exchange with SCDB.	

Learning Objective

After this module, you should be able to show an understanding of the Project's certification structure and its relationship with the regulatory framework.

Phase I - Preparation
Certification Process to Final Acceptance

- Verify that the EPC Contract Exhibits accurately track progressive completion to Final Acceptance
- Record progressive certification on the Completions Pyramid for the project

Phase I - Preparation

Certifying Authority and Regulatory Requirements

- Verify that all Witness Points, Hold Points and any particular requirement are identified
- Verify the means of tracking regulatory and certification issues
- Assign people to interface with the Certifying / Regulatory Authority if none exist in the project team
- Establish Witness and Hold Points pertinent to Commissioning and Start Up.
- Cultivate a first-class relationship with external agents from the Certifying / Regulatory Authority

Learning Objective

At the conclusion of this module you will show understanding of the contents of API RP 1FSC, create a visual representation of the Systems Completion process, produce the structure of a Turnover Completion Package and be able to demonstrate the need for agreement with Operations to determine Handover requirements.

Phase I - Preparation
Handover / Turnover Procedures

- The work flows, procedures and documentation to support the process is known as the Turnover Completion Package, (TCP)
- All major Operating companies will have their own version of TCPs and the way in which Transfer of Care, Custody and Control (TCCC) is achieved
- Handover(s) to Operations are managed through the TCCC process
- Annex A of API RP 1 FSC contains a sample Turnover and Completion Package

Phase 1 - Preparation
Handover / Turnover Procedures

API RP 1FSC, 1st Edition, Annex A – Courtesy of API
Turnover and Completions Package

The following is an example table of contents for a turnover and completions package.

1) System definition:
   a) systems description;
   b) system boundaries;
   c) systems drawings;
   d) tagged data.
2) Supporting documentation:
   a) as-commissioned PIDs, block diagrams, single line diagrams;
   b) blind list;
   c) preservation records;
   d) LOTO/software bypass log;
   e) start-up spares;
   f) MSDS.
3) Mechanical completion records:
   a) installation ITRs;
   b) certificates;
   c) punch list.
4) Pre-commissioning records:

Phase 1 - Preparation
Handover / Turnover Procedures

API RP 1FSC, 1st Edition, Annex A – Courtesy of API

a) test procedures;

b) "B" completed check sheets;

c) punch list items.

5) Commissioning records:

a) commissioning procedures;

b) completed "C" check sheets;

c) punch list items.

6) Vendors:

a) site reports and drawings;

b) spare parts and special tool list;

c) documentation.

7) Operational, start-up and performance testing:

a) PSSR;

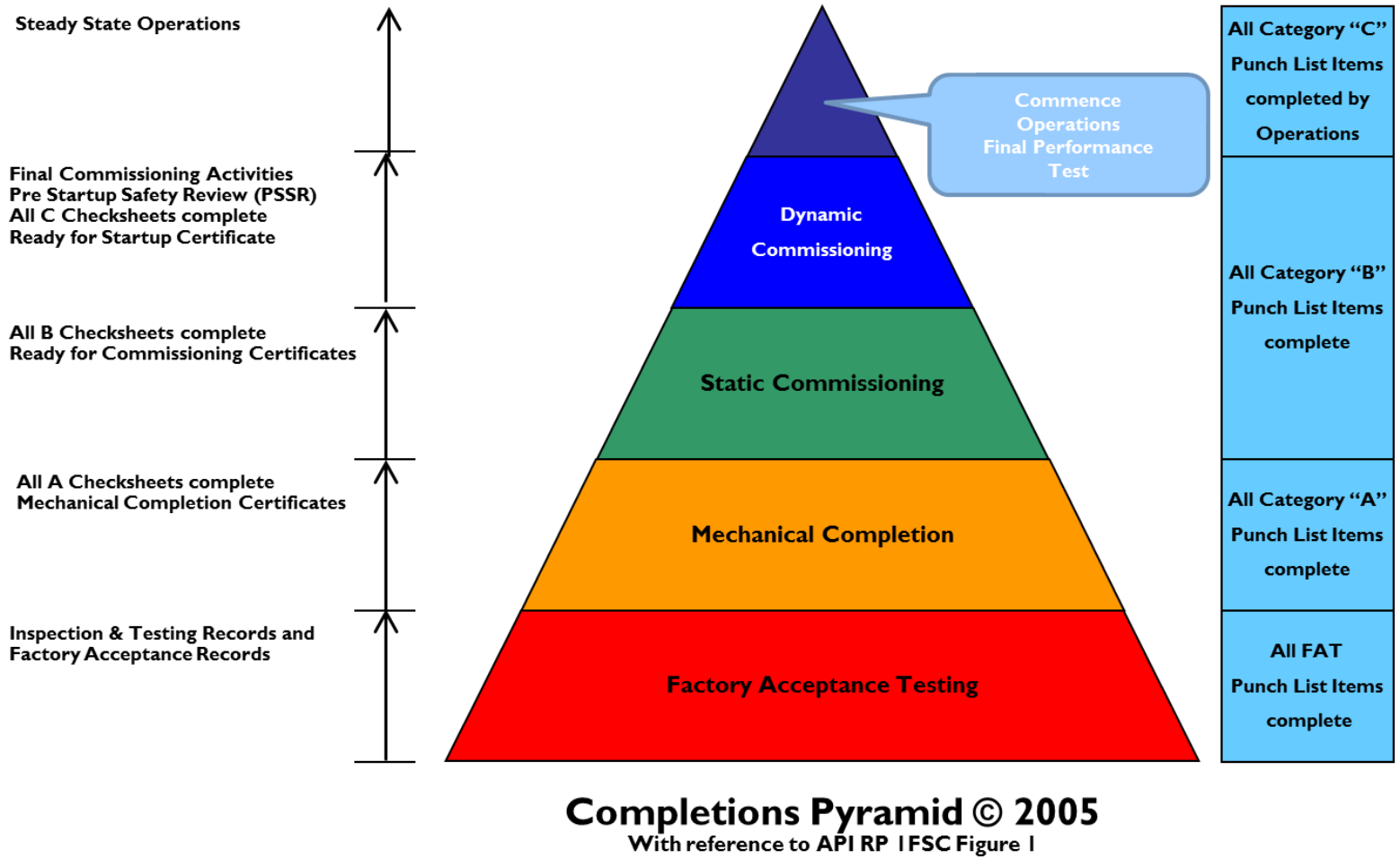
b) start-up procedure;

c) performance test procedure.

8) Management of change (MOC).

9) Regulatory documents.

Phase 1 - Preparation
Create the Completions Pyramid



Completions Pyramid © 2005
With reference to API RP 1FSC Figure 1

Learning Objective

After this module, you will be able to demonstrate knowledge of when Design Reviews are carried out, by whom, when and why, articulate the need for Commissioning to actively participate in HAZOP Studies, explain how to conduct a "Lessons Learned" program and describe how to create Best Practices.

Phase I - Preparation

Design Reviews, HAZOP and Risk Analysis -I

At key stages during FEED and Detailed Design, a number of design reviews will be carried out. These will include:

- Layout and 3-D model reviews
- P&ID / Process Flow Diagram (PFD) reviews
- Piping Isometrics reviews
- Risk Assessments and Hazard & Operability (HAZOP) Studies

Phase 1 - Preparation

Design Reviews, HAZOP and Risk Analysis - 2

- Design reviews are an essential part of the process of good engineering design and project management
- The value to the project is that issues identified during the design phase will be many times less costly to rectify than when discovered during Construction
- Cost ratios may be in the order of 1:1000
- $1 of design may cost more than $1,000 in the field
- With serious implications to the project schedule

Phase I - Preparation
Design Reviews, HAZOP and Risk Analysis - 3

- As defined by Wikipedia, "*A hazard and operability study (HAZOP) is a structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation.*
- *The HAZOP technique was initially developed to analyze chemical process systems, but has later been extended to other types of systems and also to complex operations such as nuclear power plant operation and to use software to record the deviation and consequence.*
- *A HAZOP is a qualitative technique based on guide-words and is carried out by a multi-disciplinary team (HAZOP team) during a set of meetings."*
- Refer to British Standard BS IEC 61882:2001 - Hazard and Operability Studies (HAZOP studies)

Phase 1 - Preparation

Design Reviews, HAZOP and Risk Analysis - 4

Outline of Methodology

- The method applies to processes (existing or planned) for which design information is available. This commonly includes a PFD, which is examined in small sections, such as individual items of equipment or connecting pipework. For each of these a design Intention is specified.

- For example, in a chemical plant, a pipe may have the intention to transport 2.3 kg/s of 96% sulfuric acid at 20° C at a pressure of 2 bar from a pump to a heat exchanger. The intention of the heat exchanger may be to heat 2.3 kg/s of 96% sulfuric acid from 20° C to 80 ° C. The HAZOP team then determines what are the possible significant Deviations from each intention, feasible Causes and likely Consequences.

- Then decide whether existing, designed safeguards are sufficient, or whether additional actions are needed to reduce risk to an acceptable level.

- Specialist software is used for documenting and recording outcomes from HAZOP meetings.

Phase I - Preparation

Design Reviews, HAZOP and Risk Analysis - 5

For guidance on how to perform Hazop Studies, refer to the embedded file.

Adobe Acrobat Document

Phase I - Preparation

Design Reviews, HAZOP and Risk Analysis - 6

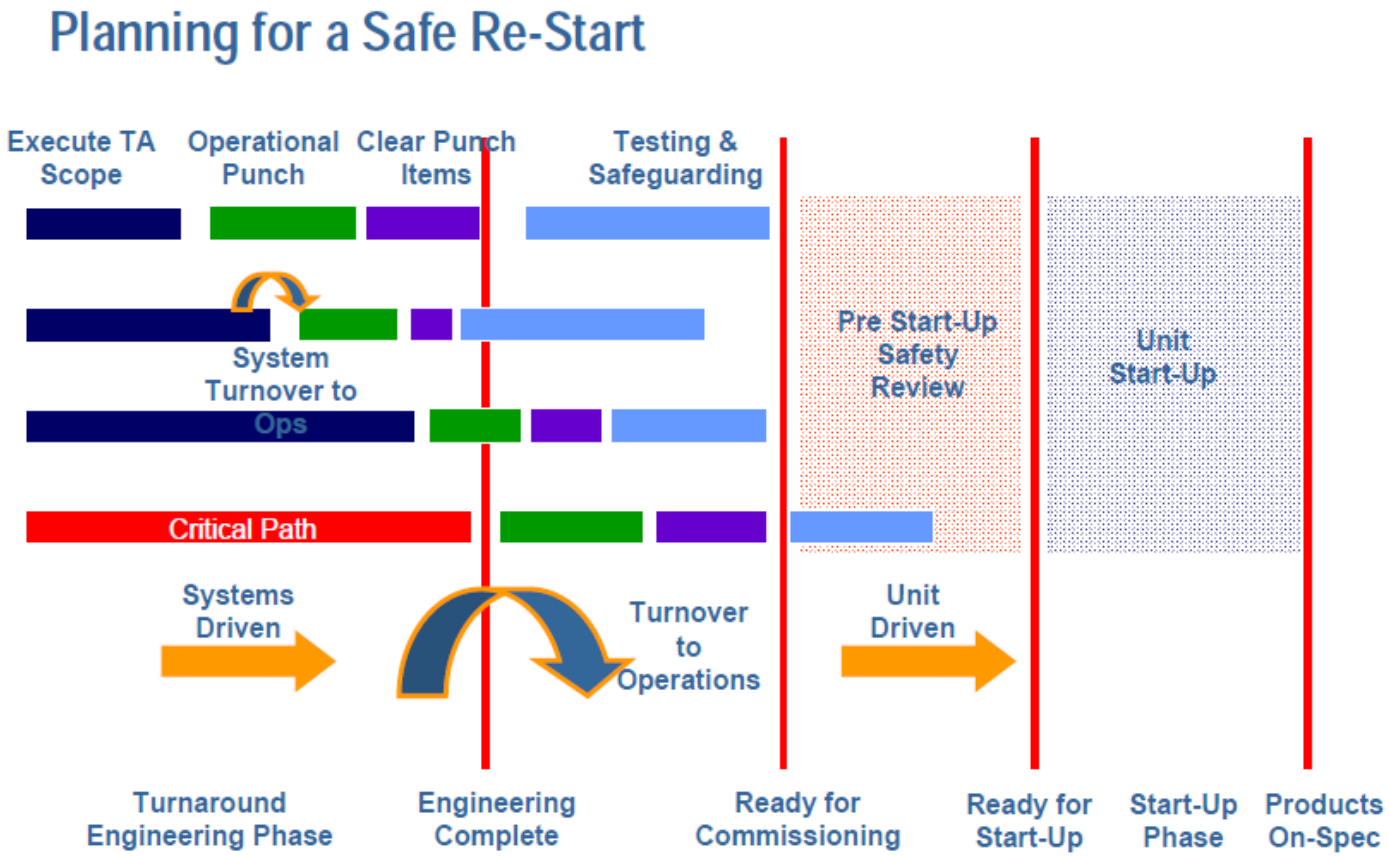
- All major Operating companies have their own version of performing Hazard & Operability (HAZOP) Studies.
- Examples from Chevron and Shell are shown on the next 2 slides
- Chevron – Hazard Identification (HAZID)

Adobe Acrobat Document

Phase I - Preparation

Design Reviews, HAZOP and Risk Analysis - 7

Shell – Flawless Start Up Initiative (FSI)



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Phase I - Preparation

Risk Analysis / Assessment - I

Phase I - Preparation
Risk Analysis / Assessment - 2

Two Sides of the Same Coin

- API RP 1 FSC is a good example
- Lessons Learned, over many years from many projects, assessed by SMEs from major Operators to form a Best Practice.
- API RP 1 FSC does not talk about the way ***projects have been completed*** or ***are being completed***, but about the way ***projects should be completed***.

Phase I - Preparation

Make Lessons Learned become Best Practices - I

Phase I - Preparation

Make Lessons Learned become Best Practices - 2

Step 1 - Create a Safe Environment

Phase I - Preparation

Make Lessons Learned become Best Practices - 3

By three methods we may learn wisdom:
First, by reflection, which is noblest;
Second, by imitation, which is easiest; and
Third by experience, which is bitterest.

Confucius

Step 2 - Allow Time for Reflection

Phase I - Preparation

Make Lessons Learned become Best Practices - 4

Step 3 – Begin to Gather Ideas

Phase I - Preparation

Make Lessons Learned become Best Practices - 5

Step 4 - Ask Some Questions

Phase I - Preparation

Make Lessons Learned become Best Practices - 6

Why, exactly is this important?

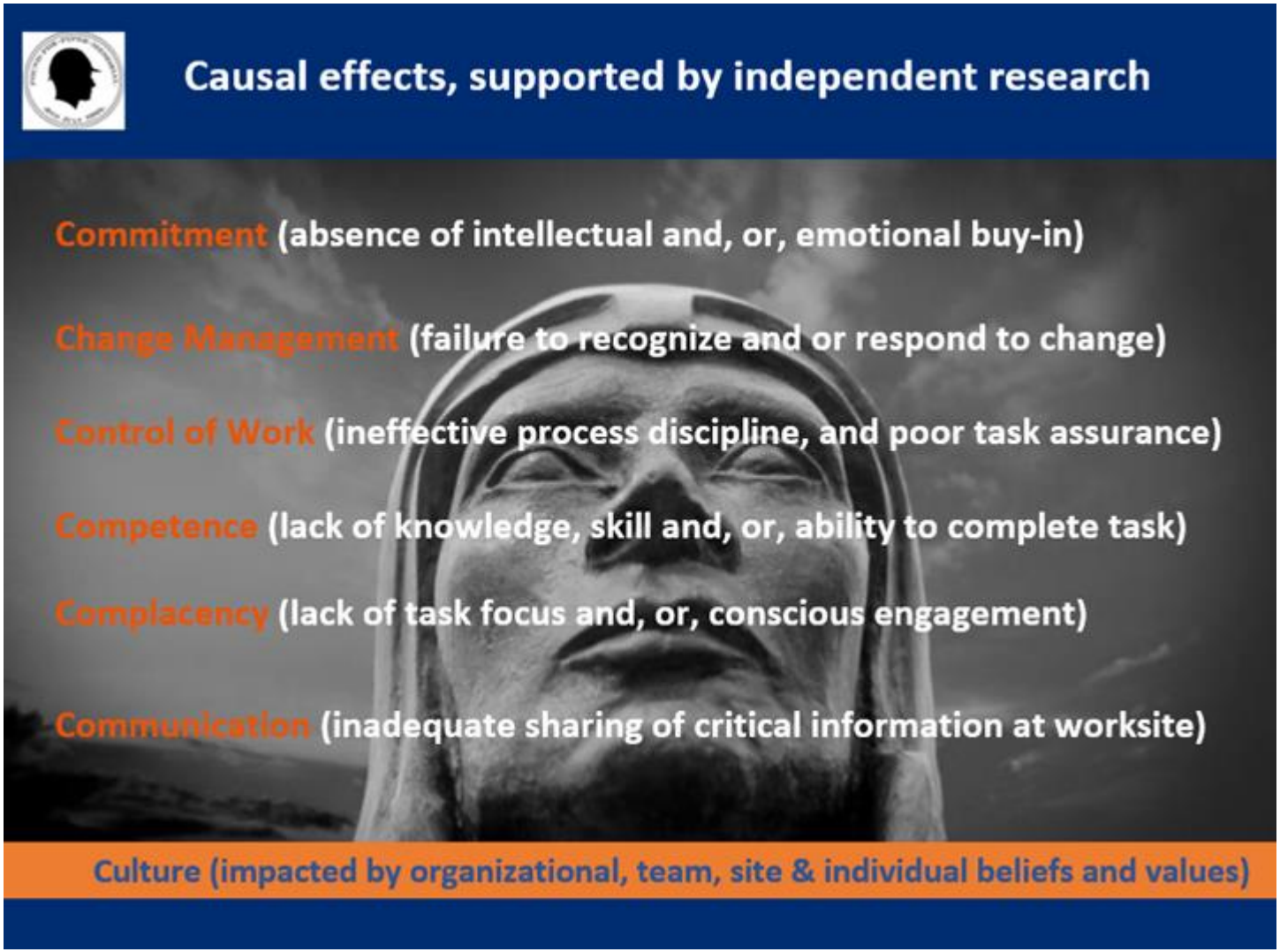
As an engineer, technician, operator or manager, you must get out on the job and walk around, eyes open, sensors on full alert and actively consider on-the-job behaviors.

Be prepared to question what is happening and why.

From BP *Macondo*, be prepared to Stop Work if you believe the situation warrants this action.

Phase I - Preparation

Make Lessons Learned become Best Practices - 7



Phase 1 - Preparation

Make Lessons Learned become Best Practices - 8

Steve Rae, Piper Alpha survivor: I refer to these as my six Cs:

- *Commitment*
- *Change management*
- *Control of work*
- *Competence*
- *Complacency*
- *Communication*

Note, no mention of ALARP, Golden rules hazard management etc.

The 6 Cs are far more fundamental than other elements used to support HSE activities across industry. The following slide reveals what you may see when these Cs are overlooked within your organisation or at your worksites.

Phase I - Preparation

Make Lessons Learned become Best Practices - 9

Why, exactly is this important?

Refer to the embedded file from Professor Andrew Hopkins of Australian National University reporting on a senior management visit to *Deepwater Horizon* just hours before the BP *Macondo* well started flowing disastrously out of control.

Hopkins–Lessons from Management W

Learning Objectives 1

By completing this module you will show understanding of the contents of API RP 1FSC, with respect to the need for planning, reproduce the structure of a typical Commissioning Plan, restate the activities to evaluate & select a SCDB

Learning Objectives 2

You will be able to explain when a Commissioning budget should be created and state budgetary parameters in terms of project size and identify factors affecting performance.

You will also be able to demonstrate knowledge of estimating norms, know where these are obtained, how they are applied and what the limitations are.

The Commissioning Plan

Commissioning & Start Up Workshop

The Commissioning Plan - I

The Commissioning Plan is a method statement, read in conjunction with the project schedule, of the activities and work processes to be undertaken by the Commissioning Team.

On projects where a specialist contractor or firm of consultants will be engaged to populate the Commissioning Team and perform the work until Close Out, a Commissioning Plan will be particularly useful.

In such circumstances, the Owner may produce an initial release of the Commissioning Plan for the selected contractor or firm of consultants to further develop.

The Commissioning Plan will become a "living document' which the Commissioning Team will use as their Bible and against which their performance will be measured by the Owner.

Commissioning & Start Up Workshop
The Commissioning Plan - 2

A Commissioning Plan will typically be structured as:

1. Purpose of the Commissioning Plan
2. Commissioning Overview
3. Scope of Work
4. Aims and Objectives
5. Commissioning Team Roles
6. Commissioning Methodology
    a. Prepare
    b. Implement
    c. Close Out
7. Initial Commissioning Systems
8. The Systems Completion Database (SCDB)
9. Commissioning and Start Up Challenges.

Commissioning & Start Up Workshop

The Commissioning Plan - 3

Detailed contents will include:

1. System P&IDs marked up in Systemization process
2. Inhibits and Isolations Register
3. All Checksheets and procedures for Cleaning, Drying, Leak Testing
4. All Certificates and Notices:

   Construction ➔ Commissioning

   Commissioning ➔ Operations
5. Actions from HAZOPs
6. All Queries and Management of Change documents
7. Commissioning Procedures
8. Start-Up Procedures (if different)
9. Authority to introduce hydrocarbons / process media

Commissioning & Start Up Workshop

The Commissioning Plan - 4

Systems Completion Planning and Organization Activities, API RP 1 FSC, Table 1

Recommended FEED Activities	Recommended Detailed Engineering Activities
a) Develop Systems Completion strategy	a) Perform SC risk assessment
b) Develop Systems Completion execution plan	b) Finalize Systems and Sub System definition and inclusion in Engineering documents
c) Develop Certification process	c) Procure and implement SCDB
d) Review Asset Register and ensure Systems Completion (SC) Database requirements are included	d) Obtain and track vendor Inspection Release Notice (IRN) and PLIs in SCDB
e) Produce Systems and minimum System testing requirements and acceptance criteria	e) Develop Permit to Work (PTW), Lockout/Tag out (LOTO) system
f) Produce initial Startup sequence with milestones and integrate into Project Schedule	f) Produce site SC turnover procedure 1) Define Certification process 2) Prepare turnover completion package (TCP) 3) Finalize milestones and schedule
g) Identify risks based on Startup sequence	g) Purchase Commissioning and Startup spares
h) Produce SC scope for execution contracts	h) Witness and track Factory Acceptance Tests
i) By System, identify required function tests, tie-ins, Commissioning and/or Startup procedures	i) Review project redline procedure
j) Identify and plan regulatory requirements	j) Produce and finalize the following: 1) SC execution plan 2) SCDB execution plan 3) Equipment Preservation

API RP 1FSC, 1st Edition, Table 1 – Courtesy of API

Justifying a Budget, Allowing for Growth

Commissioning & Start Up Workshop

Justifying a Budget, Allowing for Growth - I

- Little information in the public domain
- Estimating scope, schedule and budget is not easy
- Limited collaboration between Operators and Contractors
- Each maintaining their own knowledge bases and their own norms
- Information has been in a silo

Commissioning & Start Up Workshop

Justifying a Budget, Allowing for Growth - 2

- Elements that should form the budget
- How to allow for growth
- Norms from recent projects to estimate the overall budget
- Projects vary with industry, types of processes, location and other factors, such as workforce competency
- Some broad guidelines are available
- For overall commissioning services at an **onshore chemical plant**:
  - 3.5% of total capital investment is in Commissioning & Startup
  - Approx. 70% in Trade costs
  - Approx. 30% in Consumables

Commissioning & Start Up Workshop

Justifying a Budget, Allowing for Growth - 3

Discipline	Code	AITRs	BITRs
Architectural	C	1.00	-
Electrical	E	7.20	11.23
HVAC	H	5.00	10.33
Instrumentation	I	2.91	3.86
Piping	L	5.10	3.20
Structural	N	3.00	-
Mechanical	R	6.97	9.95
Safety	S	3.60	8.20
Telecoms	T	4.68	4.60
Insulation	U	4.00	-
Surface Protection	X	3.50	-
Demolition	Z	2.00	-
Average Manhours:		**5.63**	**8.83**

Discipline	Code	BITRs
Electrical	E	15.73
HVAC	H	7.76
Instrumentation	J	11.31
Mechanical	M	13.33
Telecoms	T	8.54
Average Manhours:		**11.33**

Estimating Norms (left) and Actual Average Manhours (below) from North Sea projects from 2005 to 2015.

BITR	Average Manhours
Electrical	12.4
Instruments	7.3
F&G	15.0
HVAC	6.0
Telecoms	2.0
Mechanical	9.1
Piping	12.0
Process	16.0
Safety	7.2
Average =	**9.7**

Notes

The figures shown in these tables are taken from an actual project in Norway. When considering your project, take into account factors such as location and competency of the workforce. Poor productivity as a result of poor planning and management were factors in these examples.

Commissioning & Start Up Workshop
Justifying a Budget, Allowing for Growth - 4

Taking averages across all Disciplines of the norms and actual manhours we have:

AITRs = 5.6

BITRs = 10.0

In the next section, these figures will be applied to two actual projects to determine an allowance for productivity and punch listing.

Estimating Commissioning Manhours

We looked at two projects recently completed, in which we were involved.

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Justifying a Budget, Allowing for Growth - 5

What we knew:

- **Project 1 - FPSO, Asia Shipyard**
  - SE Asia Shipyard, Developed Country, Benign Environment, Good Site Controls
  - Final billings for work activities related to A, B & C ITRs, ***including Punch List Items***
  - Ratio of AITRs and BITRs to Tags
  - Number of Systems and Sub Systems
  - Number of CITRs
- **Project 2 - Oil & Gas Plant**
  - Remote Location, Justifying Country, Harsh Environment, Site Controls Challenged
  - Final billings for work activities related to A, B & C ITRs, ***including Punch List Items***
  - Ratio of AITRs and BITRs to Tags
  - Number of Systems and Sub Systems
  - Number of CITRs

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Justifying a Budget, Allowing for Growth - 6

What we didn't know:

- **Project 1 - FPSO, Asia Shipyard**
  - Estimated Manhours per AITR and per BITR
  - Actual productivity
  - Actual Punch Listing activity, separate from billings for AITRs and BITRs
- **Project 2 - Oil & Gas Plant**
  - Estimated Manhours per AITR and per BITR
  - Actual productivity
  - Actual Punch Listing activity, separate from billings for AITRs and BITRs

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Justifying a Budget, Allowing for Growth - 7

We made some assumptions:

- Commonality exists in many of the Checksheets (ITRs) on projects, Onshore or Offshore, in a Shipyard or at a Gas Plant in a Justifying country.
- Productivity at the Shipyard was good, assumed to be 1.00.
- The two projects were of similar size, with a similar number of Systems and were comparable.

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Justifying a Budget, Allowing for Growth - 8

Then stated our method:

1. In Project 1, by knowing the total billings of direct labour to perform Systems Completion and Commissioning Scope, in other words, the AITRs, BITRs & CITRs, but not the estimated manhours, actual productivity or Punch Listing, we applied the Manhour norms for AITRs, BITRs & CITRs from previous projects to Project 1 and compared these with Project 2, total billings of direct labour to perform Systems Completion and Commissioning Scope, in other words, the AITRs, BITRs & CITRs allowing for the actual productivity and Punch Listing.

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Justifying a Budget, Allowing for Growth - 9

Then stated our method:

2. We normalised each project to have a Tag Count of 50,000, with 100 Systems and 250 Sub Systems, then by knowing the ratios of AITRs and BITRs to Tags, we calculated the direct manhours to complete AITRs, BITRs & CITRs in Project 1 and subtracted these from Project 2, to leave the manhours that can be attributed to actual productivity and punch listing.

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Justifying a Budget, Allowing for Growth - 10

Points to consider:

- Types of processes
- Geographic location
- Management ability and site control
- Workforce productivity and competency

Actual billings ***including punch listing*** reflect quality and productivity
Project 1 - Tag Count of **50,000,** (normalised) billings of **1,500,000**
AITRs per Tag = **3**
Manhours per AITR = **5.6**
BITRs per Tag = **1**
Manhours per BITR = **10.0**
CITRs per Sub System = **1**
Manhours per CITR = **100**
Calculation: 50,000*((3*5.6)+(1*10.0))+250*100 = **1,365,000**
Total Manhours, including punch listing, assuming productivity of 1.00

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Justifying a Budget, Allowing for Growth - 11

- Assume Project 1 has good productivity of 1.00
- A total of 1,365,000 manhours were billed to A, B & C ITRs
- Punch listing accounts for 1,500,000-1,365,000 = 135,000 manhours
- On Project 1, each Tag had 135,000/50,000 = 2.7 manhours of punch list activity, assuming productivity of 1.00.
- Project 2 had (normalised) actual billings of **2,100,000** direct manhours to complete the scope of A, B & CITRs ***including Punch List Items***.
- Therefore, deducting 1,365,000 from 2,100,000 leaves **835,000** manhours in **Project 2** that could be attributed to productivity and punch listing.
- Project 2, each Tag was billed for **17.4 manhours** over and above the "estimated amounts" from this exercise.
- Site control, quality issues, plus remote location, in a Justifying country with poor access to supplies and materials.
- Refer to the embedded files for estimating a commissioning budget derived from norms and actual project information.

Commissioning & Start Up Workshop

Justifying a Budget, Allowing for Growth - 12

Broad Metrics:

Manhours per ITR	
Oil & Gas Project	Average Manhours all Disciplines
AITRs	5.60
BITRs	10.00

Productivity & Punch Listing		
Manhours	Good, assumes pf = 1.00	Poor
Per Tag	2.70	17.40

Estimating Norms and Actual Manhours

Factors to be aware of:

- **Productivity Factor**
- **Punch Listing**

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Commissioning & Start Up Workshop

Justifying a Budget, Allowing for Growth - 13

Key Points on Budgeting:

- **Total budget is important**
- **It is all about *How* …**
- **… not so much about *How Much***
- **Pay Now or Pay Later**
- **Failure costs much more than Success**

Learning Objective

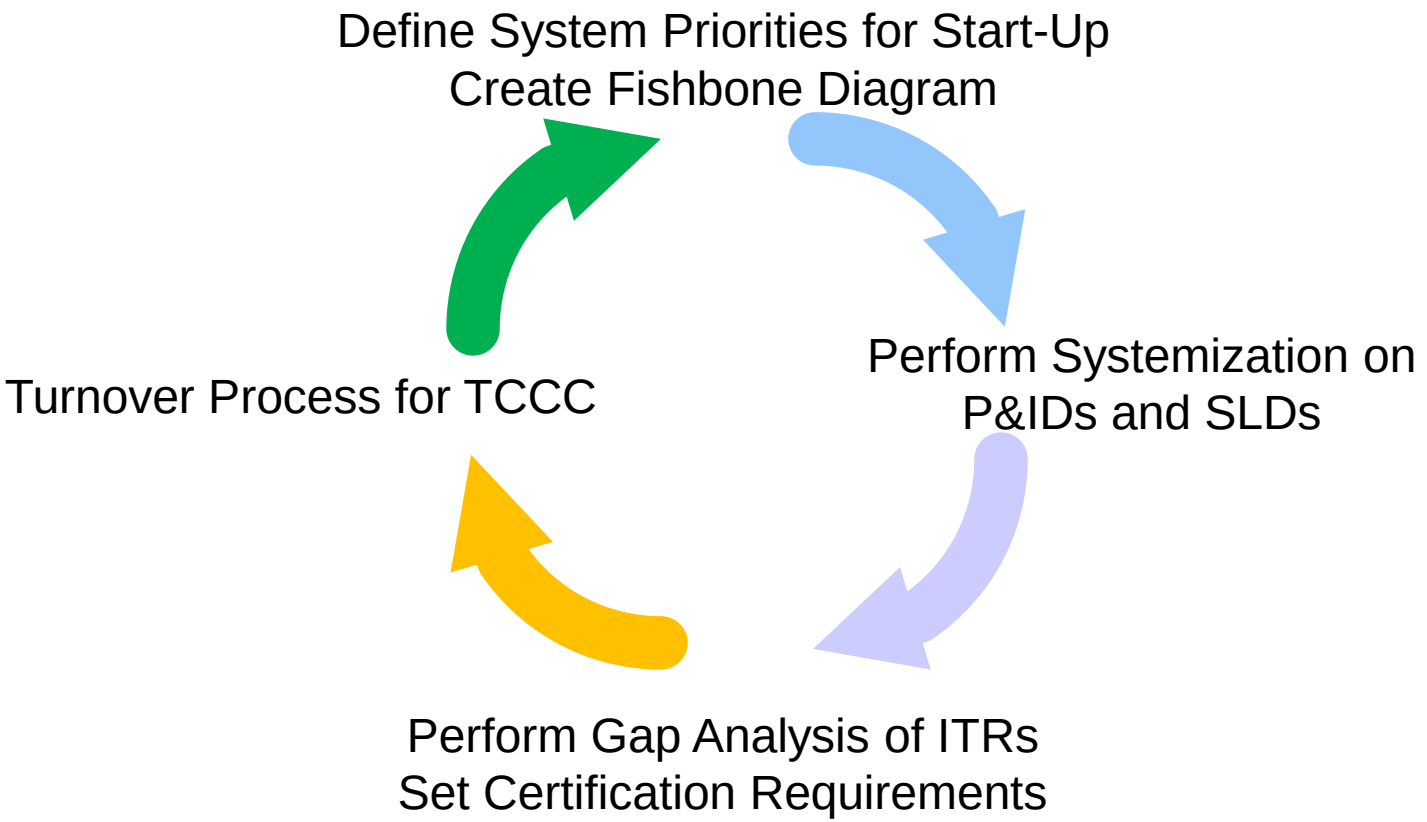
On completing this module you will be able to identify the key Stakeholders and participants in the Systemization exercise, explain how Battery Limits are defined, provide a definition of a viable Sub System, articulate the contents of a Turnover Completion Package and identify the recipient.

Systemization, Priority Start-Up Sequence, and Progressive Systems Completion Methodology

Commissioning & Start Up Workshop

Systemization, Priority Start-Up Sequence, Gap Analysis, Turnover Process - I

The Overall Systemization Process



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Systemization, Priority Start-Up Sequence, Gap Analysis, Turnover Process - I

Systemization

- Guidelines
- Fishbone Diagram
- ITRs & Certificates
- Turnover Process

Systemization Guidelines From Falcon Group

Adobe Acrobat Document

Commissioning & Start Up Workshop
Systemization, Priority Start-Up Sequence, Gap Analysis, Turnover Process - I

Systemization Guidelines

- Responsibility of Commissioning Manager
- Stakeholder Buy-in
- Operating Entity
- Iterative Process

P&IDs used with Priority Systems Sequence & Fishbone Diagram
From Falcon Group

Adobe Acrobat Document

Priority Systems for Initial Start-Up

Fishbone Diagram, aka Cause & Effect: Kaoru Ishikawa

- Priority 1 (P1) Power and Safety Systems
- Priority 2 (P2) Control Systems
- Priority 3 (P3) Utilities, Air and Water Systems
- Priority 4 (P4) Storage, Mechanical Handling, Loading Systems
- Priority 5 (P5) Production & Process Systems
- Priority 6 (P6) Metering, Import & Export Pipeline Systems

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Systemization, Priority Start-Up Sequence, Gap Analysis, Turnover Process - I

Fishbone Diagram

- System Priorities for Initial Start-Up
- Add Planning Information and WBS Codes
- Add Resources
- Monitor Daily with Skyline Reports

Priority Systems Sequence & Fishbone Diagram From Falcon Group

Adobe Acrobat Document

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Systemization, Priority Start-Up Sequence, Gap Analysis, Turnover Process - I

Fishbone Diagram Example Reproduced with grateful thanks to Chevron Corporation

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Systemization, Priority Start-Up Sequence, Gap Analysis, Turnover Process - I

Gap Analysis

- ITRs & Certificates …
- All other types document needed
- Sort into 3 piles

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Systemization, Priority Start-Up Sequence, Gap Analysis, Turnover Process - I

Turnover Process

- TCCC

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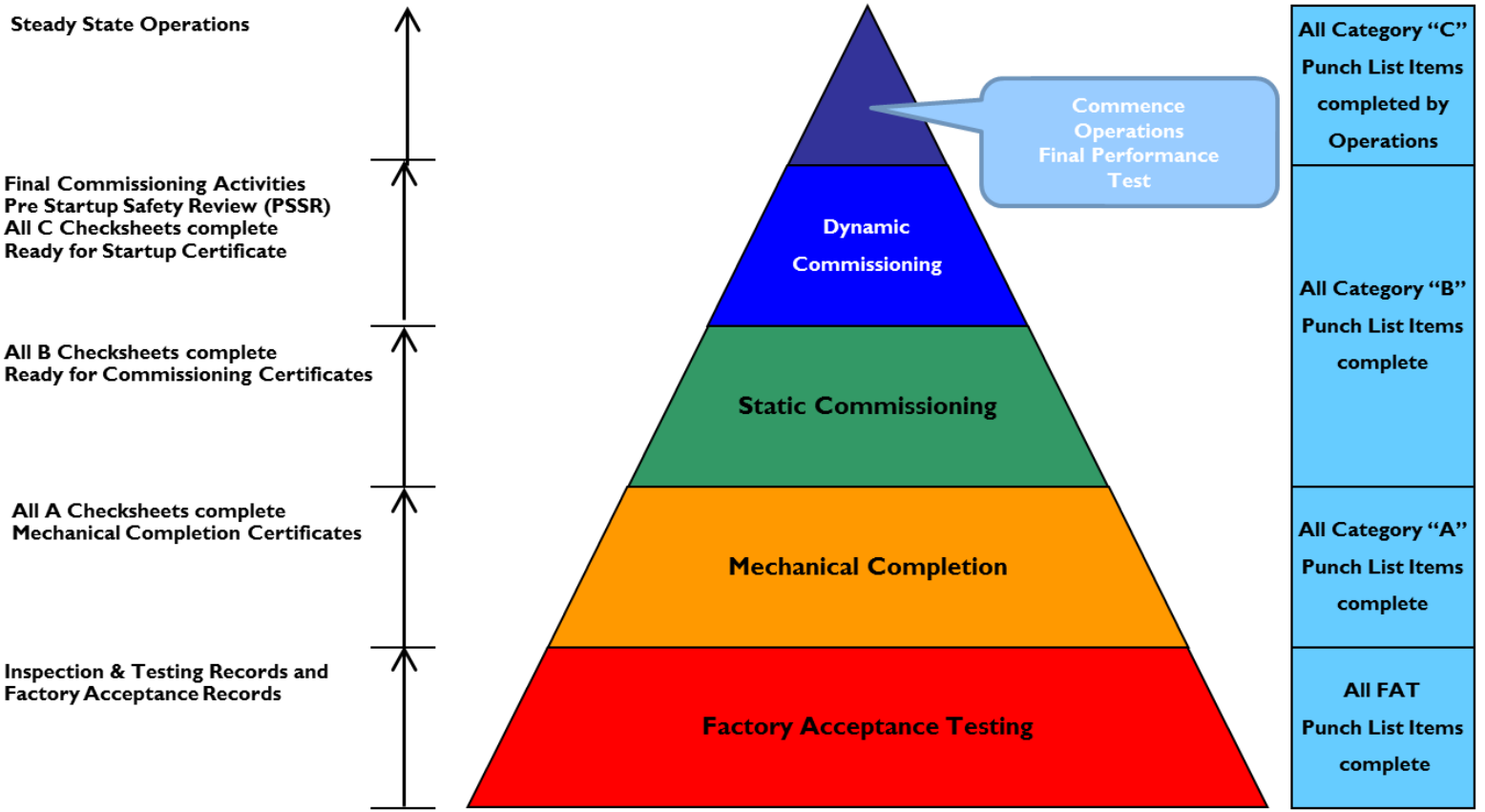
Systemization, Priority Start-Up Sequence, Gap Analysis, Turnover Process - I



Completions Pyramid © 2005

With reference to API RP 1FSC Figure 1

Tag Numbering

- Engineering are responsible for the engineering deliverables
- Engineering should have a system for Tag Numbering
- Ensure the Tag Numbering system is sufficient
- Drawing reviews of P&IDs, SLDs, Loop Diagrams to ensure every Commissionable Tag is uniquely referenced and included

Tag Numbering

- Be aware of what is not planned to be tagged as Commissionable
- For example, manually operated valves may not be assigned a unique Tag Number
- When this happens, the item is not individually recorded in SCDB and is therefore **invisible** to the system
- It is unlikely that invisible items will be listed for Preservations

Tag Numbering – Case Study 1

- A project recently completed had to be mothballed for over one year.
- The Owner was organized and ensured Preservation activities were performed on all Tagged Items.
- Unfortunately, this did not include around 8,000 manual valves.
- When the Owner thought he was ready to resume work at the facility, progress was substantially delayed to replace the manual valves, at considerable expense.

Tag Numbering – Case Study 2

- The same project, located in a country with a very severe winter climate, electrical heat tracing components were not uniquely tagged as Commissionable Items.
- Apparently, electrical heat tracing was not thought of as being too important to merit inclusion.
- When piping Systems had been pressure tested and signed off as complete, the installation of electrical heat tracing was overlooked.
- Winterisation started and the piping and equipment requiring insulation for Winterisation / personnel protection were clad.

Tag Numbering – Case Study 2 (cont'd)

- The available working window in that country is confined to about 7-8 months each year.

- When it became apparent the installation of electrical heat tracing had been missed, the delay to Startup was a further year, with significant costs arising from removal of insulation, installing and commissioning electrical heat tracing and re-installing the insulation.

Tag Numbering – Summary of Case Studies 1 & 2

- The cost and schedule impacts of these two oversights were conservatively reckoned to have incurred delays of more than one year and costs of more than $500m.

Estimating Assumption and PSCM

- Assumption - estimating norms are based on Progressive Systems Completion Methodology [PSCM]
- Fortunately, API RP 1 FSC, 1st Edition is also based on PSCM
- PSCM is the transition from an Area approach that Construction will work, to a Systems or Sub Systems approach, required on most projects for safe and timely Start Up in the shortest possible time
- The critical path of the project schedule comes from a forward and backward pass of the sequence of Systems needed in their Commissioned and Handed Over state, determining which Systems are needed first to achieve early Start Up
- For large Systems > 250 Tagged Items, spread across large areas in the Plant, then Sub Systemizing will be needed in order to maintain Construction progress and not disrupt productivity

Commissioning & Start Up Workshop

Systemization, Tag Numbering, and Progressive Systems Completion Methodology - 8

Systemization

- Systemization must be performed by a review of the P&IDs, one by one, in close consultation with Operations
- Battery limits will be marked on a color-coded set of P&IDs
- Each System or Sub System must be a logical entity that Operations will be willing to take care, custody and control of (TCCC)
- The marked up, color-coded set of P&IDs will be signed by the Stakeholders, Commissioning and Operations
- Deliverables to Operations are defined in the TCP / Handover Package

Commissioning & Start Up Workshop

Systemization, Tag Numbering, and Progressive Systems Completion Methodology - 9

Priority Systems - 1

The normal priorities for achieving Commissioning & Start Up are:

- Safety
- Utilities, with Power, Lighting, Air and Water
- Control Systems, DCS, PLCs
- Product Storage, Loading and Mechanical Handling
- Process Systems
- Hydrocarbons / Chemical Feed and Storage

For an Offshore project, activities will be dominated by achieving Essential Life Support (ELS) as the first priorities, so the first Systems to be Commissioned and made Operational along with Utilities, Telecommunications and Personnel Address are Navigation Aids, Helideck, Lifeboats, Ballast Water, Station-Keeping Systems, (Dynamic Positioning, Winches and Moorings), etc.

Priority Systems - 2

- Commissioning must get buy-in from Construction to switch from Areas to PSCM (~60%)
- Invest time with Construction, on how Area, Sub System, System progression is achieved.
- Use the Completions Pyramid - how Construction Completions are achieved with completion of the AITRs.
- Work closely with Operations and Construction, agree Sub System battery limits on the P&IDs, ensure each Sub System is an Operable Entity Operations are willing to take TCCC of.
- Marked-up P&IDs are vital documents - must be signed off by all Stakeholders: Construction, Commissioning and Operations.

Priority Systems - 3

- Produce the start-up sequence in a logical and easy to follow format.
- Use a **Fishbone Diagram** or similar to show start-up sequence .
- Do not underestimate the pressure from Construction to adhere to an Area approach for as long as possible, while at the same time, Operations really only being interested in taking care and custody of a complete System at a time.
- In addition to the Commissioning Manager's technical attributes, he or she must also be a good diplomat and negotiator, able to reach healthy compromises that are good for the project and its objective:

To Start Up safely, in the shortest possible time.

Fishbone Diagrams

According to Wikipedia, Ishikawa diagrams (also called fishbone diagrams, herringbone diagrams, cause-and-effect diagrams, or Ishikawa) are causal diagrams created by Kaoru Ishikawa (1968) that show the causes of a specific event.[1][2] Common uses of the Ishikawa diagram are product design and quality defect prevention to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of variation. Causes are usually grouped into major categories to identify these sources of variation. The categories typically include:

***People**: Anyone involved with the process*

***Methods**: How the process is performed and the specific requirements for doing it, such as policies, procedures, rules, regulations and laws*

***Machines**: Equipment, computers, tools required to accomplish the job*

Commissioning & Start Up Workshop
Systemization, Tag Numbering, and Progressive Systems Completion Methodology - 13

Fishbone Diagrams (cont'd)

***Materials**: Raw materials, parts, pens, paper, etc. used to produce the final product*

***Measurements**: Data generated from the process that are used to evaluate its quality*

***Environment**:The conditions, such as location, time, temperature, and culture in which the process operates.*

Embedded are Fishbone Diagrams from a recently completed major oil & gas production facilities project and a useful template, reproduced with grateful thanks to Chevron Corp.

Microsoft Excel Worksheet

Foxit tomPDF PDF Docu

Images of Cause & Effect Diagrams by K. Ishikawa.

Ishikawa-Cause_&_effect_diagram_Fishbone.png

Ishikawa-Cause_&_effect_diagram_Fishbone2.png

Commissioning & Start Up Workshop

Systemization, Tag Numbering, and Progressive Systems Completion Methodology - 14

Tip - 1

- Early on, during FEED, apply the Completions Pyramid for your project
- Get the Project Team used to thinking Systemically with the simplicity of the Completions Pyramid, compared with the more complex flow diagrams they may be tempted to produce
- Complex flow diagrams may impress the originator but mean little to many people on the project.
- Import the System structure and hierarchy in SCDB Check to reinforce systemic thinking in the project team, especially Commissioning and key Stakeholders, such as Construction, Operations, QA and Safety.

Tip - 2

When reviewing the Tag Numbering policy for the project, here are some guidelines:

- Ensure there is uniqueness in Tag Numbering
- Have Engineering check for duplicates
- Each Tag Number should have a Tag Name
- Ensure no Commissionable Tags are missed
- Avoid use of special characters in Tag Numbering
- If Parent and Child Tag relationships are used, this should be evident in the Tag Numbering
- Discourage the use of lengthy Tag Numbers (>20 characters)

Learning Objectives 1

By completing the activities in this module, you will be able to differentiate the roles and composition of the Commissioning Team, state their responsibilities and reproduce a typical organization chart for the Commissioning Team.

You will be able to explain when to do Audits, what a Gap Analysis is, what is being looked for and the outcomes.

Learning Objectives 2

You will be able to identify the range of reports needed to satisfy Commissioning and Project Management requirements.

You will also be able to state the contents of a well-structured Commissioning Procedure and recall recommended steps in the development of Standard Operating Procedures.

Commissioning Team Organisation, Recruitment and Training

Commissioning & Start Up Workshop

Commissioning Team Organisation, Recruitment and Training - I

The Commissioning Team size will depend on the size and complexity of the project. Experienced engineers must be recruited in sufficient numbers so that the dates in the project schedule can be adhered to.

On the basis of technical ability, **Lead Commissioning Engineers** will be assigned specific Sub Systems and Systems to effectively own and manage, supported as required by other Commissioning Engineers in the team.

Spread evenly over the project duration, the **Lead Commissioning Engineers** will probably have several Sub Systems and Systems assigned to them and be responsible for procedure development, design reviews with Engineering, HAZOPs, coordination with Procurement through FAT activities.

In addition, monitoring of Preservations and checks performed during Construction, Commissioning until eventual Handover to Operations with supporting documentation.

Commissioning & Start Up Workshop

Commissioning Team Organisation, Recruitment and Training - 2

It will be the Commissioning Manager's responsibility to ensure there is the correct blend of skill sets in the Commissioning Team, as well as sufficient resources.

Typically, and depending on the specifics of the industry, the project and its processes, engineers and technicians of Electrical, Instrumentation & Controls, Mechanical (Rotating Equipment) and Process disciplines will be needed, all should have Operations experience.

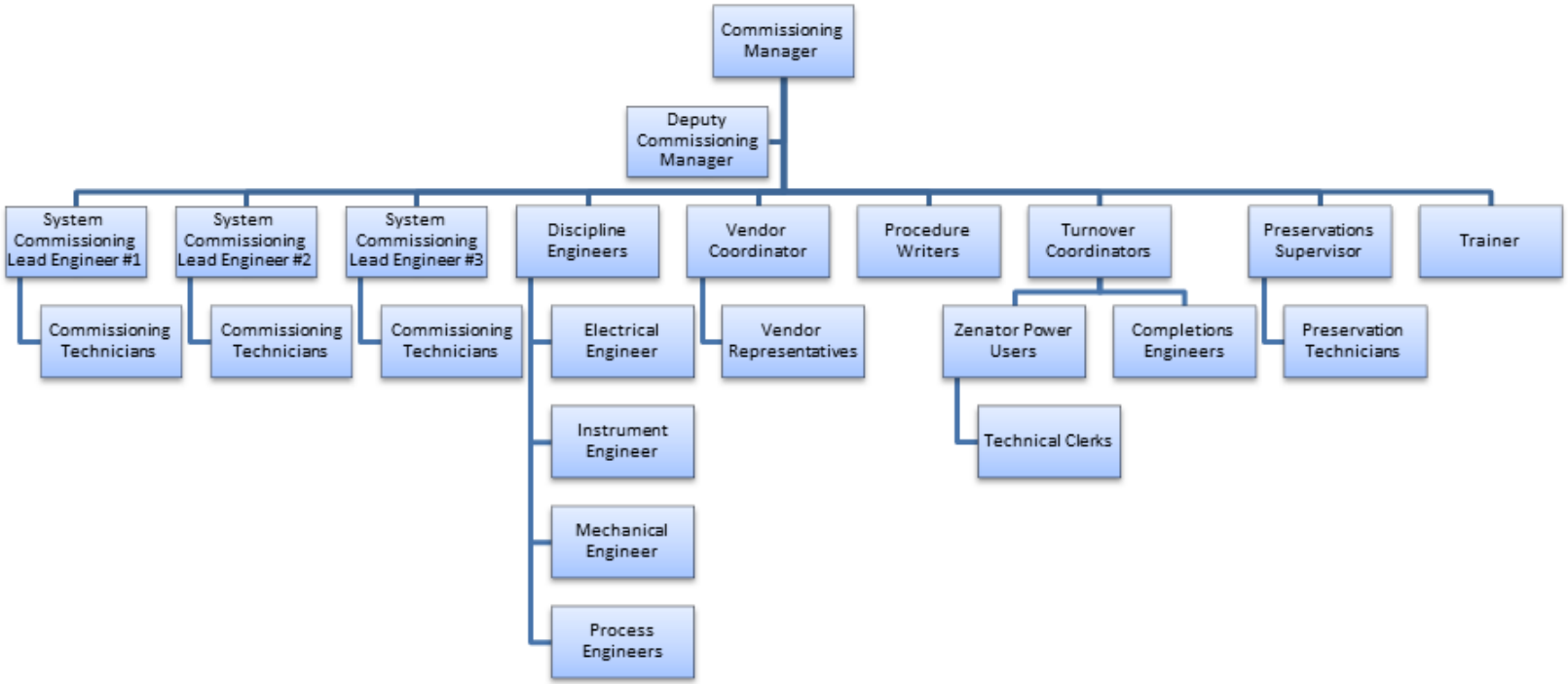
On many projects it is normal for Operations to supplement the Commissioning Team with engineers and technicians from Production and Maintenance departments.

This will serve the interests of the Commissioning Team, fulfilling objectives, while also providing valuable training for the engineers and technicians from Operations in how the plant is Started Up, Shut Down and will operate.

Commissioning & Start Up Workshop

Commissioning Team Organisation, Recruitment and Training - 3

A suggested organisation chart for a Commissioning Team is shown below:



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Commissioning Team Organisation, Recruitment and Training - 4

Commissioning Manager

Reporting to the Project Manager, with overall responsibility for all Commissioning & Start Up activities to Close Out. Will liaise closely with peers in Construction and Operations and all key Stakeholders.

Deputy Commissioning Manager

Reporting to the Commissioning Manager, with delegated responsibility for assigned Commissioning & Start Up activities to Close Out. Closely coordinates "hands-on" activities of the Commissioning Team when the Commissioning Manager is engaged with project meetings, politics, etc.

Commissioning & Start Up Workshop

Commissioning Team Organisation, Recruitment and Training - 5

Lead Commissioning Engineer

Reporting to the Commissioning Manager, with responsibility for all activities through Completions Pyramid for Commissioning & Start Up of specific Systems. Supervises engineers and technicians providing assistance as needed. Coordinates with Discipline Engineers and calls for support when required. May develop System Commissioning Procedures or liaise with Procedure Writing Group within the Team. Will have a hands-on role in the development, review and approval of the System Commissioning Procedures nominated his or her responsibility.

Discipline Engineers – Electrical, Instruments, Mechanical & Process

Reporting to the Commissioning Manager and providing support to Lead Commissioning Engineers.

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Commissioning Team Organisation, Recruitment and Training - 6

Turnover Coordinators

Supported by Completions Engineers, *SCDB* Power Users and Technical Clerks. Liaising closely with Construction and Operations through all Turnovers.

Procedure Writers

Reporting to the Commissioning Manager and liaising closely with Operations and the Lead Commissioning Engineers in the development of System Commissioning Procedures. Responsible for the production of all System Commissioning Procedures, aka Operational Test Procedures (OTPs) and Standard Operating Procedures.

Trainers

Reporting to the Commissioning Manager and liaising closely with Operations in the development of classroom and on-the-job training (OTJ) of engineers and technicians from Production and Maintenance, and new recruits.

Auditing and Gap Analysis

Commissioning & Start Up Workshop

Auditing and Gap Analysis - I

The Commissioning Manager with his or her team will need to ensure all procedures and documentation required to commission and start up the Plant on time and safely are all in place. Periodic audits will be needed to review, understand and amend as necessary what exists, and a gap analysis must be performed to discover what doesn't yet exist.

Audit

- Review, understand and amend as necessary what exists
- Compare the synchronous nature of the many procedures
- Highlight gaps, inconsistencies, contradictions and overlaps
- Look for touch points, interfaces, clear boundaries and definition of responsibilities

Commissioning & Start Up Workshop
Auditing and Gap Analysis - 2

Gap Analysis

- Assess what is needed to Commission & Start Up on time and safely
- Look for what is missing, identify and action

As a Guide:

- Commissioning Manual or Commissioning Plan
- Project Commissioning Philosophy
- Commissioning Strategy
- Mechanical Completion Manual
- Project Schedule
- Progress Reporting structure
- Factory Acceptance Testing (FAT) procedure

Commissioning & Start Up Workshop
Auditing and Gap Analysis - 3

Gap Analysis Guide (continued)

- Factory Acceptance Testing (FAT) scope and schedule
- Tag Type Matrix (TTM)
- Checksheets required
- System Commissioning Procedures required
- Standard Operating Procedures required
- Change Management System
- Punch List procedure
- Permit to Work System
- Energization Notice / Livening Up Notice
- Electrical / Mechanical Inhibit / Isolation procedure

Commissioning & Start Up Workshop
Auditing and Gap Analysis - 4

Gap Analysis Guide (continued)

- Tie-in Points
- Handover to Operations procedure
- Handover from Construction procedure
- Preservation procedure
- Vendor coordination procedure
- QA / Certifying Authority / Regulatory Requirements

Develop Standard Operating Procedures

Commissioning & Start Up Workshop

Develop Standard Operating Procedures - I

Circulate Knowledge and Company Formats

Use the Company format for SOPs as the template for System Commissioning Procedures

Lead Commissioning Engineer / Procedure Writer

Prepare the System Commissioning Procedures and issues as first draft of SOPs, written on Company template

Develop Training Materials around SOPs

The Lead Commissioning Engineer / Procedure Writer liaises with Trainer to prepare training materials

Lead Commissioning Engineer / Procedure Writer

Operations look to hire Lead Commissioning Engineer / Procedure Writer or at a minimum advise on further development of SOPs

Commissioning & Start Up Workshop

Develop Standard Operating Procedures - 2

Guidelines for Standard Operating Procedures

According to OSHA, Employer shall develop and operate written procedures that provide clear instructions for safely conducting activities involved in each covered process, consistent with the process safety information and shall address at least the following:

- Steps for each operating phase
- Initial start up
- Normal operations
- Temporary operations
- Emergency shut down (ESD)
- Emergency operations
- Normal shut down
- Start up after turnaround or ESD
- Operating limits
- Consequences of deviation
- Steps required to correct or avoid deviation

- Safety and health considerations
- Properties of, and hazards presented by, the chemicals / hydrocarbons used in the process
- Precautions necessary to prevent exposure, including engineering controls, administrative controls and PPE
- Control measures to be taken if physical contact or airborne exposure occurs
- QC for raw materials and control of hydrocarbons / hazardous chemical inventory levels

Sample Commissioning Procedures

Commissioning & Start Up Workshop

Sample Commissioning Procedures - 1

Commissioning Procedures are:

- Bespoke documents prepared by experienced engineers and produced for each System on every Project;
- Logical, sequential and very detailed descriptions of how each commissionable System and its Tagged Item components integrate to operate that System;
- Valuable control documents that record readings and comments made during actual System Commissioning, initialling each stage and for sign-off by authorised individuals on completion;
- Commissioning Procedures describe how the Facility will be initially Started Up and Shut Down.

Commissioning & Start Up Workshop

Sample Commissioning Procedures - 2

Crude and Diesel Fuel Systems

These procedures with marked up P&IDs are excellent examples taken from a recent FPSO project, supplied by Gareth Knight:

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Sample Commissioning Procedures - 3

Stabilization Unit Start-Up & Shutdown

This procedure is from a recent onshore Gas Processing plant, supplied by Gareth Knight:

Crude and Diesel Fuel Systems

Systemized P&ID with Battery Limits:

60-FCA	LIQUID FUEL SYSTEMS - RAW & TREATED CRUDE OIL

60-FCA-501	Raw Crude Fuel Oil Transfer System	
63-FCA-502	Treated Crude Fuel Oil Transfer System	

08	10A	BALLAST STARBOARD	
08	10B	BALLAST PORT	
09	06A	SEA WATER PUMP STBD.	
09	06B	SEA WATER PUMP PORT	
09	06C	SEA WATER PUMP MUD PITS	

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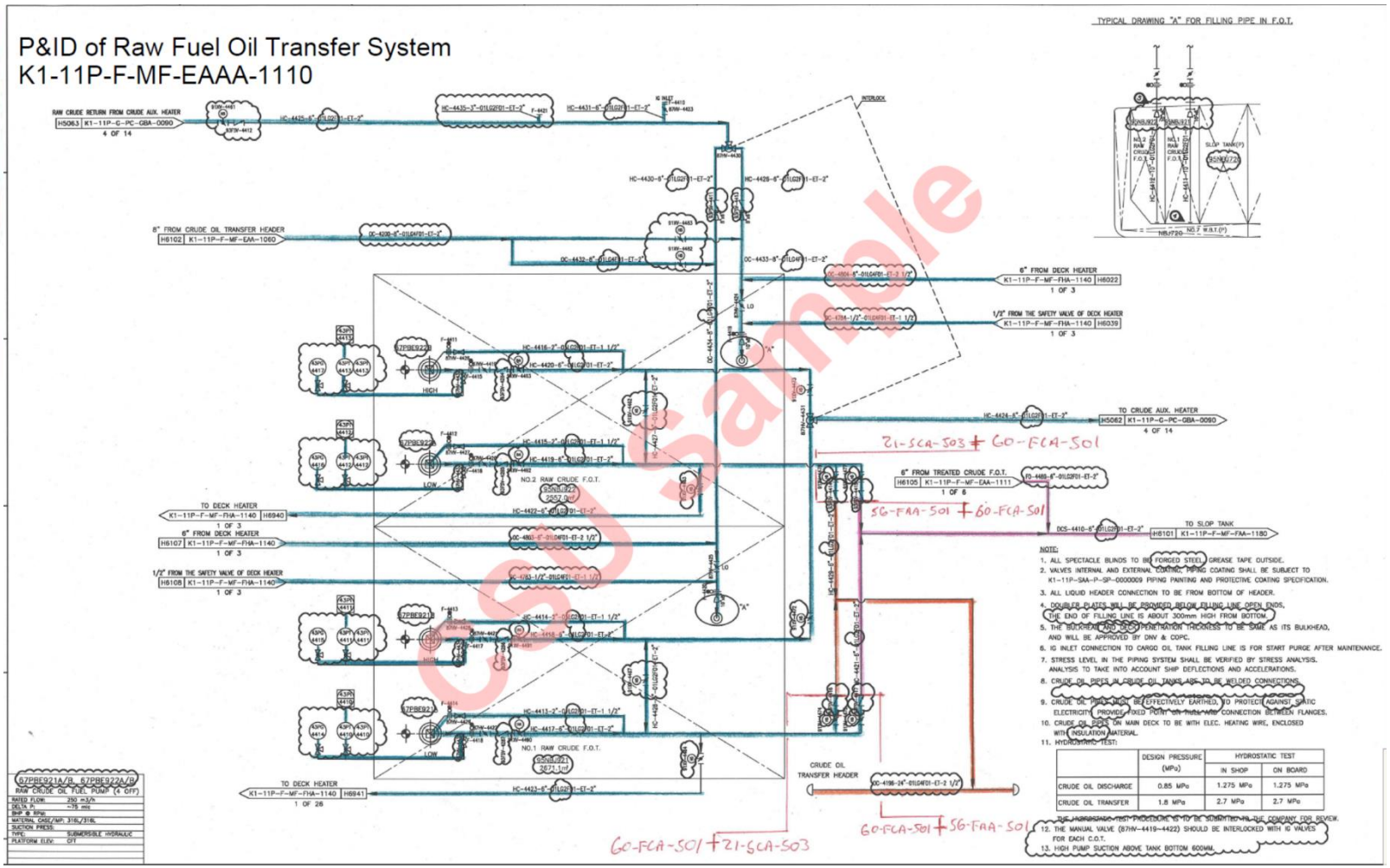
Sample Commissioning Procedures - 5

Crude and Diesel Fuel Systems



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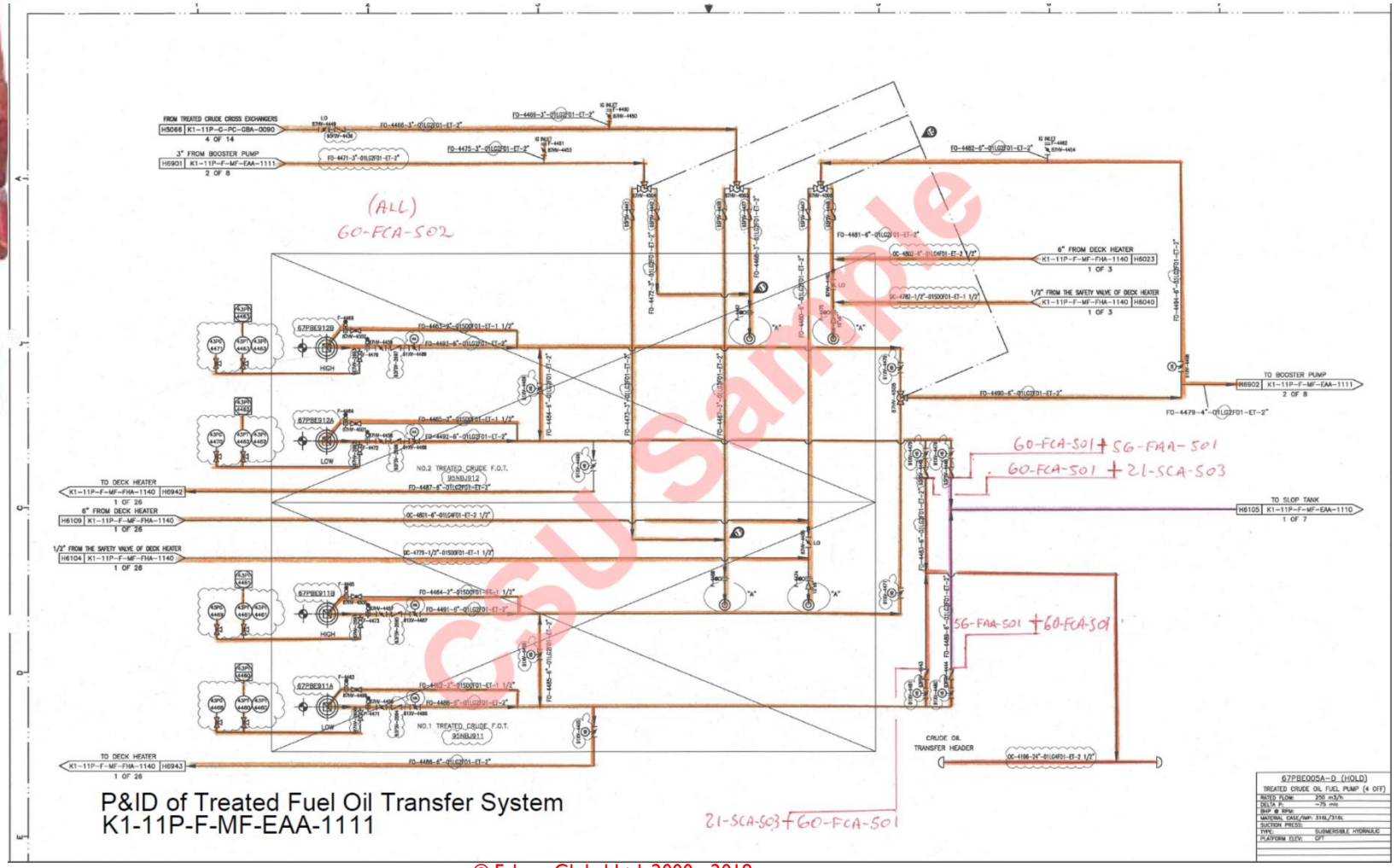
Sample Commissioning Procedures - 6

Crude and Diesel Fuel Systems



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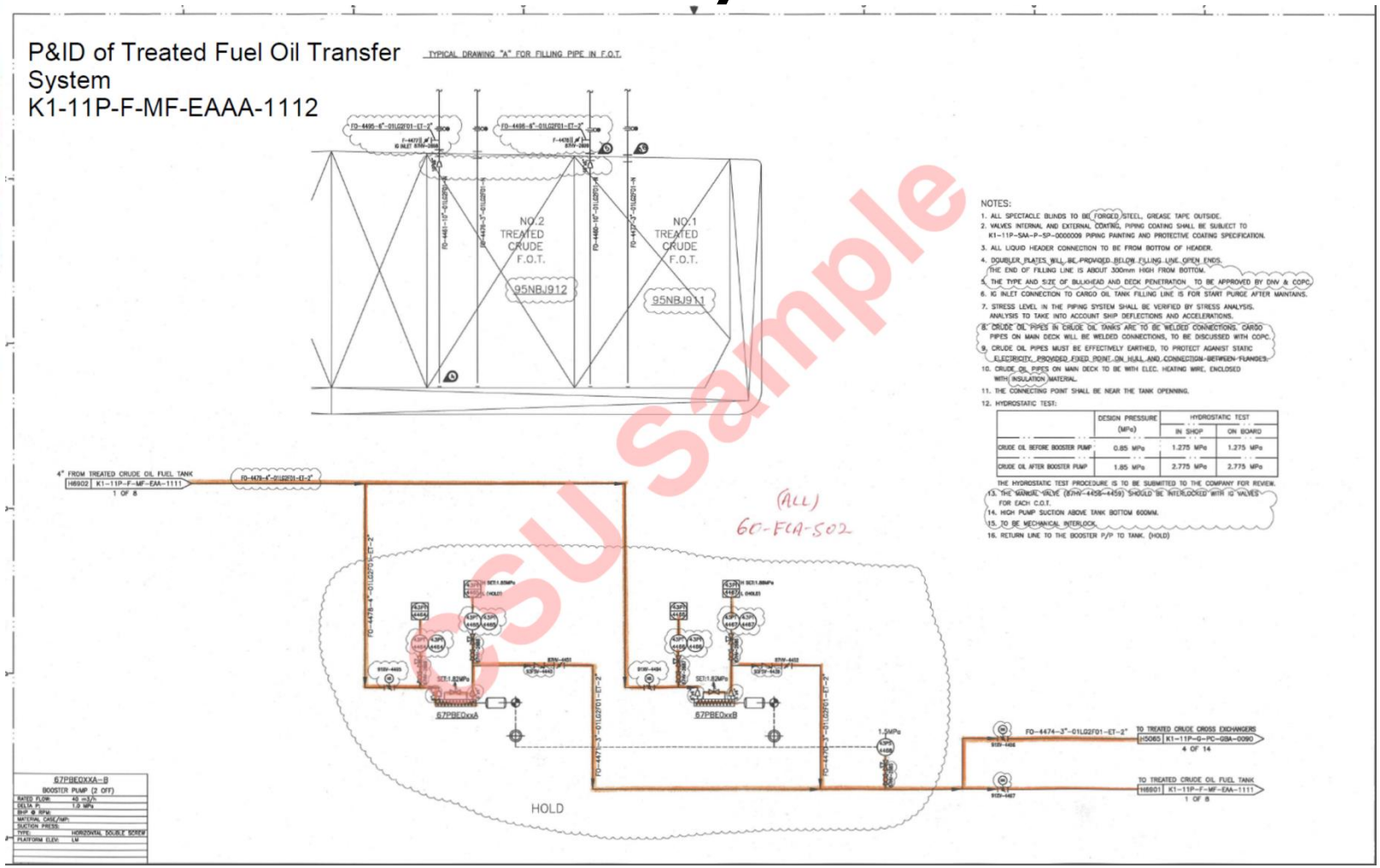
Sample Commissioning Procedures - 7

Crude and Diesel Fuel Systems



Sample Commissioning Procedures

Sample Commissioning Procedures - 8

Fuel Gas System

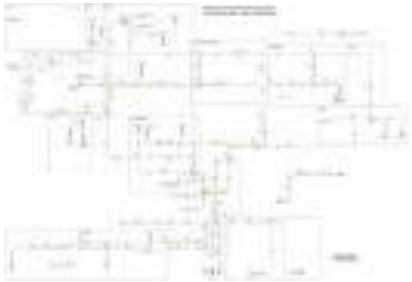
Adobe Acrobat Document

Methanol System

Adobe Acrobat Document

Commissioning & Start Up Workshop

Sample Commissioning Procedures - 9



Fuel gas is one of a number of fuels that under ordinary conditions are gaseous. Many fuel gases are composed of hydrocarbons (such as methane or propane), hydrogen, carbon monoxide, or mixtures thereof. Such gases are sources of potential heat energy or light energy that can be readily transmitted and distributed through pipes from the point of origin directly to the place of consumption.

Fuel gas is contrasted with liquid fuels and from solid fuels, though some fuel gases are liquefied for storage or transport. While their gaseous nature has advantageous, avoiding the difficulty of transporting solid fuel and the dangers of spillage inherent in liquid fuels, it also has limitation. It is possible for a fuel gas to be undetected and collect in certain areas, leading to the risk of a gas explosion. For this reason, odorizers are added to most fuel gases so that they may be detected by a distinct smell.

The most common type of fuel gas in current use is natural gas..

Commissioning & Start Up Workshop

Sample Commissioning Procedures - 10

Commissioning & Start Up Workshop

Sample Commissioning Procedures - 11

Commissioning & Start Up Workshop

Sample Commissioning Procedures - 12

Table of Contents

Commissioning & Start Up Workshop

Define Reporting Requirements

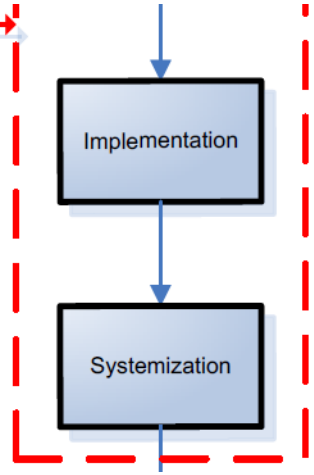
A license for SCDB will have been purchased in Step 3 of the Simplified Commissioning Logic.

Refer to API RP 1 FSC Tab 1, Systems Completion Planning and Organization Activities

Step 3 – Implementation
Within 3 months of Start of Detailed Design

Step 4 – Systemization
Within 6 months of Start of Detailed Design

Steps 5, 6 & 7 – Mobilize, Reporting, Work Flows
Within 9 months of Start of Detailed Design



- Purchase license for *Zenator* (SCDB)
- Engage Specialist Subcontractors
- Raise POs for Specialist Equipment
- Participate in Systemization, HAZOPs with Operations and Engineering
- Identify Checksheets and Tag Type Matrix
- Monitor Scope, Schedule & Budget, refine if needed
- Develop RACI, Work Processes for Commissioning
- Finalize Performance Testing criteria
- Plan mobilization to Site(s)
- With Operations and Engineering, set Battery Limits on P&IDs
- Define Reporting requirements in *Zenator* (SCDB)
- Agree Handovers with Construction and Operations
- Produce Documentation and *Zenator* Reports
- Start populating *Zenator* with Project Data

The project team as a whole will need to consider reporting requirements from SCDB. These may be known and constant across larger organizations, and present in SCDB (SCDB), but projects often define particular report requirements to be developed. Make allowance for this.

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Define Reporting Requirements

Some generic report types are:

- *Overall project status, System Completion status, Handover and Certification status*
- *Checksheet Completion by ITR type, Punch List Completion by Category*
- *Management of Change status, Inhibits & Isolations status, WBS and Activity Completion status*

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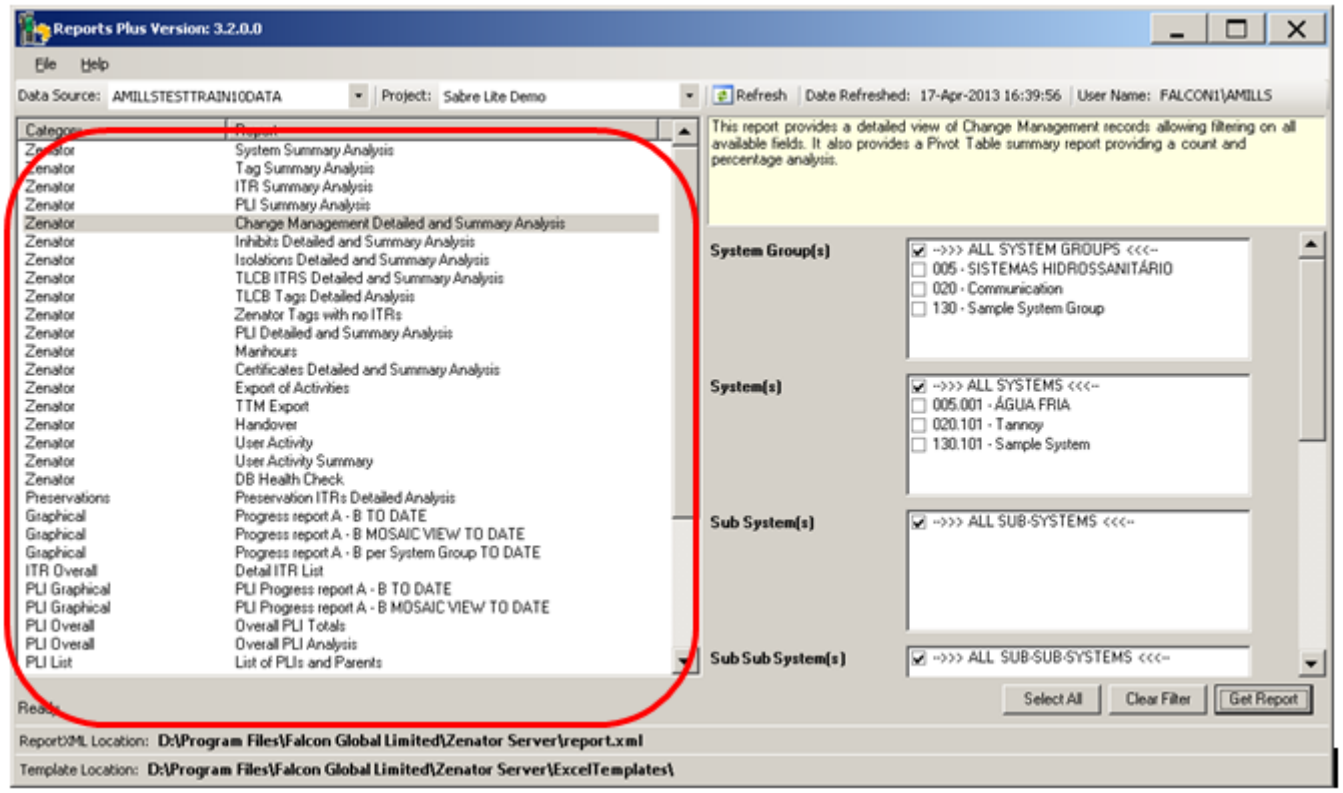
Define Reporting Requirements

Some of the many report formats present in Reports Plus supplied with Zenator (SCDB). For more information, see embedded files on page 157 of the course notes.



Learning Objectives I

After completing this module, you will know: the importance of Commissioning Spares, how to quantify and when to procure these items; the type of specialist services required for Commissioning and when these are required; how to quantify specialist services required for Commissioning on a Project.

Learning Objectives 2

You will know: how to assess the comparative strengths and weaknesses of Leak Detection methods; the pros and cons of onshore testing versus offshore testing; the purpose of Compressor Testing, String Testing and the use of Load Banks; specific issues related to working Offshore and Subsea; the considerations of scope, schedule and budget for Offices, Logistics, Equipment, Chemicals and Consumables.

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Commissioning Spares

Although referred to as Commissioning Spares, this usually means all spare parts and consumables required for Construction, Pre-Commissioning and Commissioning, up to final Handover to Operations.

Defining and identifying the spare parts needed through Commissioning and Start-Up is often left for the vendors to decide. Sometimes, separate contracts are placed with vendors, solely for the provision of spare parts through the phase Commissioning and Start-Up.

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Commissioning Spares

Refer to embedded file:

amesak-spir.pdf

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Commissioning Spares

As a general principle, leaving the identification and recommendation for the supply of commissioning spares to the vendors, can appear costly but could be extremely prudent and mitigate potential schedule delays, particularly if the project is located in a remote area or Justifying country.

Liaise closely with Package Engineers to ensure they are aware of Commissioning's requirements and these are being complied with.

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Commissioning Spares

All unused spare parts from the Commissioning and Start-Up phase will be turned over to Operations and supplement the overall inventory.

Therefore, the advice given here, is with many other important considerations to make, the Commissioning Manager, based on experience, should satisfy him or herself as to the adequacy of vendors' recommendations and make additions where needed.

Commissioning & Start Up Workshop
Specialist Services

Assess the scope of work to quantify, plan for and engaging the specialist services and contractors that will be needed. As a minimum these will normally include:

- ***Calibration and Test Equipment***
  - *Relief Valve*
- ***Inspection Equipment***
  - *Boroscope (aka, borescope)*

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Specialist Services

- ***Cleaning***
  - *Chemical Cleaning*
  - *Mechanical Cleaning*
  - *Pipeline Pigging*
  - *Pneumatic Blowing*
  - *Steam Blowing*
  - *Hot Oil Flushing*

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Specialist Services

- ***Leak Detection***
  - *Helium*
  - *Nitrogen*
- ***Test Media***
  - *Water*
  - *Nitrogen*

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Specialist Services

- ***First Fills and Lubricants***
- ***Utilities***
  - *Water*
  - *Diesel*
  - *Drainage*
  - *Temporary Power*
    - *Generators*
    - *Load Banks*

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Specialist Services - Compressor Testing

- Onshore testing of Compressor Trains at Vendor / Specialist Supplier facilities is a considerable benefit to the project schedule and FAT program, and will usually be performed with an inert gas such as Nitrogen, Helium or a refrigerant.
- Having a full run test of the Compressor Trains onshore, at the factory, will be a major cost saving in avoiding problems at a later stage on location.
- Offshore, and with safety being the primary consideration, testing with Nitrogen has an important role to play, especially if a full onshore test has not been performed or has carried over to the Offshore phase of the project.

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Specialist Services - Compressor Testing

You will:

- Perform a first-time full operational run of the Compressor Trains in conjunction with the process control system (PCS);
- Observe and adjust settings in the Compressor Trains' control system, including Run Up and Run Down time;
- Problems and defects are likely to be detected during the first full operational run;
- Perform Condition Monitoring for noise, vibration and temperature;
- Monitor consumption and make adjustments;
- The adequacy of spare parts supplied by the Vendor will be evident
- If the FAT was a no-load test, this will be the first time the Compressor Train will be run on load;

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Specialist Services - Compressor Testing

- In an Onshore environment at the Vendor's facilities, any deficiencies recorded in the above items can be relatively easily overcome and additional spares procured, compared with testing in an Offshore environment.
- If testing in an Offshore environment becomes necessary, in addition to all normal safety considerations, you will also need to consider bed space on the facility.
- Specialist personnel will be needed for testing Offshore and these will reduce the number of other people that might also need to be Offshore at that time.
- Any work in an Offshore environment is costly, running from three times the cost of equivalent work Onshore.
- Consider also the disruptive effect on the schedule of other work not being to be progressed due to safety reasons or lack of bed space.

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Specialist Services - Compressor Testing

Tip

- Ensure the scope of testing the Compressor Trains with Nitrogen is performed Onshore at the Vendor / Specialist Supplier facilities, and is included in the original Purchase Order..

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Specialist Services – Load Banks

With grateful thanks to Wikipedia for the following definition, "*a load bank is a device which develops an electrical load, applies the load to an electrical power source and converts or dissipates the resultant power output of the source.*

The purpose of a load bank is to accurately mimic the operational or "real" load that a power source will see in actual application. However, unlike the "real" load, which is likely to be dispersed, unpredictable and random in value, a load bank provides a contained, organized and fully controllable load.

Consequently, a load bank can be further defined as a self-contained, unitized, systematic device that includes load elements with control and accessory devices required for operation.

Whereas the "real" load is served by the power source and uses the energy output of the source for some productive purpose, the load bank serves the power source, using its energy output to test, support or protect the power source".

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Specialist Services – Load Banks

Load Banks are used for the commissioning of the:

- Main Power Generators and the Power Management System

This System is always on the critical path

- Uninterruptable Power Supply (UPS)
- Emergency Generator Set

Factors to consider when deploying the use of Load Bank facilities are schedule, availability and cost. In most cases, Load Banks are rental items and will be supplied by a specialist equipment supplier.

Commissioning & Start Up Workshop

Specialist Services – String Testing

- Major items of rotating equipment tested at Full Speed, Full Load and Full Pressure, under controlled conditions at the factory, onshore.
- Gas compressors, water injection pumps or power generation turbines.
- A series of exhaustive full-load tests conducted at the vendor facility as part of the FAT, to verify performance and functionality of each turbo-compressor string.
- See the example from an LNG facility, the critical nature of rotating equipment in the liquefaction chain demanded rigorous levels of testing.
- Vendors that manufacture major capital equipment, such as gas compressors and power generators are often equipped to conduct a string test on complete trains at full load, perhaps up to 100 MW, replicating plant operating conditions, enabling performance verification and mechanical behavior of the units, as specified in the Operator's requirements.

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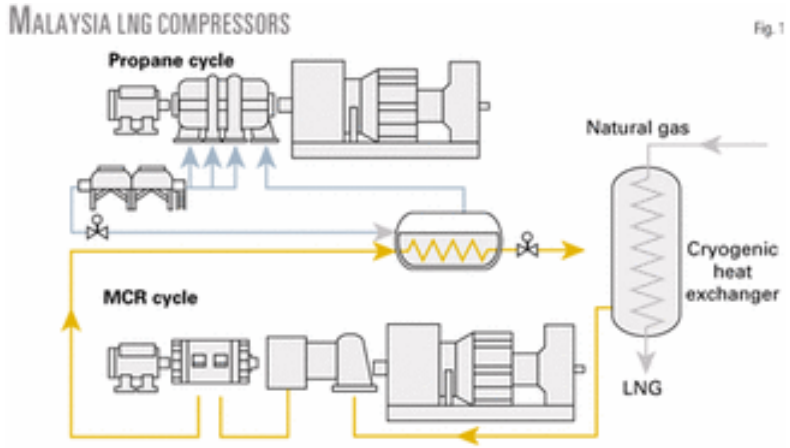
Specialist Services – String Testing



- Fig. 1 Malaysia LNG (MLNG) Tiga compressor configuration.
- The mixed-refrigerant (MR) cycle uses a GE FR-7EA gas turbine with an ISO power rating of 86 MW driving an AN 200 (low-pressure) axial compressor and a 2BCL 806 (high-pressure) centrifugal compressor.
- A 10 MW variable speed electric motor assists in train start-up and as a helper when needed.
- The propane cycle uses a similar gas turbine driver and electric motor starter-helper driving a 3MCL 1405 centrifugal compressor.

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Specialist Services – String Testing

- The embedded file is a technical paper describing integration testing during FAT and at the MLNG Tiga facility in Bintulu, Sarawak, Malaysia.

Commissioning & Start Up Workshop

Specialist Services – String Testing

- The embedded file contains of the design and string testing of turbo machinery for Chevron operated Gorgon project in Western Australia, the world's largest CO facility.

Commissioning & Start Up Workshop

Specialist Services – String Testing

Tip

- Ensure the scope of commissioning the main power generators, including supply of Load Banks and a String Test, are part of the Vendor/Specialist Supplier's original PO.
- Ensure the Commissioning Manager and key discipline leads from Commissioning, review the scope of the String Test with Operations, and participate in the tests at the vendor's facility.
- Full load string testing of turbo-machinery is a costly, requiring meticulous planning, but better to expose design flaws and equipment failures at the vendor facility than in the field, which could easily be a remote location with no access to resources or the necessary spare parts, than during Commissioning.
- String testing must be well performed, recorded and documented. Commissioning and Operations will then have experience of the rotating machinery being tested at full load and access to valuable performance information.

Commissioning & Start Up Workshop

Specific Offshore and Subsea Issues

Good Commissioning Management is about managing interfaces well, and nowhere will any flaws or discrepancies be more acutely felt than with Offshore activities, especially Subsea activities. Key points to consider are:

- Build and maintain excellent relations, good communications are vital;
- Engage all Stakeholders early on to ensure the scope of work and particular requirements – people, materials, equipment and access are defined and understood;
- The Stakeholders; the OIM, Operations, Safety, QA, Project Team, Main Contractor, Specialist Sub Contractors, Vendors, Regulatory / Certifying Authority;
- Work closely with the OIM and his delegates, Operations, Safety, Contractors and Specialist Sub Contractors to ensure the scopes of work are fully understood and the interfaces are clear, with no gaps or overlaps;

Commissioning & Start Up Workshop

Specific Offshore and Subsea Issues

- Develop lines of reporting and limits of responsibility, as above, ensure these are fully understood and the interfaces are clear, with no gaps or overlaps;
- Coordinate activities to "test one time" and avoid or at least minimise any re-testing;
- Always pay heed to the weather and other external factors over which you must be mindful, but have no control;
- Be aware other work will be going on around you and you are not the only show in town;
- Other vessels or contractors may have work taking place that requires sharing of resources and courtesy;
- Minimize risk and exposure by scheduling work when there is the longest weather window;

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Specific Offshore and Subsea Issues

Before starting work:

- Ensure all people, materials, equipment and access are in place;
- Deliver a presentation to OIM and his delegates, Operations, Safety and the Project Team about the work to be performed, the objectives, risks, mitigations;
- Deliver a separate presentation to Contractors and Specialist Sub Contractors and the Project Team, optionally with OIM, Operations and Safety if they wish to attend, about the work to be performed, the objectives, risks, mitigations;
- Factor issues arising into the plan and make adjustments;
- If something is missing, consider the cost and schedule impact of delay, compared with the cost and schedule impact of postponing the work until all requisite elements - people, materials, equipment and access - are in place;

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Specific Offshore Issues

- Commissioning Offshore involves considerations over and above an Onshore plant or facility. The Project Schedule is going to be dominated by achieving Essential Life Support (ELS) as the first priorities, so the first Systems to be Commissioned and made Operational along with Utilities, Telecommunications and Personnel Address are Navigation Aids, Helideck, Lifeboats, Ballast Water, Station-Keeping Systems, (Dynamic Positioning, Winches and Moorings), etc.

Class Certification for Floating Vessels

- Offshore facilities take many forms, from fixed or floating Platforms, Spars, semi-submersible vessels, ship-shape vessels and barges.
- Any floating vessel will have an additional set of considerations known as "Class", requiring additional interfaces with certifying Classification Societies such as American Bureau of Shipping (ABS), Lloyds Register of Shipping (LR), Bureau Veritas (BV), Det Norske Veritas (DNV) and others.

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Specific Offshore Issues

- A classification society is a non-governmental organization that establishes and maintains technical standards for the construction and operation of ships and offshore structures. The society will also validate that construction is according to these standards and carry out regular surveys in service to ensure compliance with the standards. To avoid liability, they explicitly take no responsibility for the safety, fitness for purpose, or seaworthiness of the ship or structure.

Floating Production Storage & Offloading (FPSO) Vessels

- In many respects, the Commissioning of Offshore vessels can be grouped together and coarsely categorised as Plant Commissioning plus Marine and Offshore-specific Systems. FPSOs can be included in this category up to the point of the feature that makes FPSOs unique – the Turret.

Commissioning & Start Up Workshop

Specific Offshore Issues

- The Turret and its interaction with the FPSO Mooring Systems present unique challenges requiring specialist skills.
- All planning and implementation activities described in these course notes, specifically with respect to selection of expertise within the Commissioning Team, choice of specialist Vendors / Supplier, Quality Control and FAT, must be followed for the Turret.

Tip

- Never take unnecessary risks. This is true anywhere, but especially so Offshore. The Offshore environment can be very unforgiving.

Commissioning & Start Up Workshop

Specific Subsea Issues

- For Subsea operations you will probably be reliant on the Installation Contractor providing the vessel spread to also develop all installation procedures and checks;
- Subsea operations are not known for following Progressive Systems Completion Methodology (PSCM);
- There is every reason that Installation Contractors should follow PSCM, not least for consistency;
- This will be particularly beneficial for integration of subsea umbilicals, risers and flowlines (SURF) with topsides, say in the case of a FPSO;

C:\Users\Alan\
op\INTSOK-SURF_

Tip

- Engage the Installation Contractor during FEED and DE.
- Apply the Completions Pyramid and the same PSCM to Subsea as well as Topsides.

Commissioning & Start Up Workshop

ffices, Logistics, Equipment, Chemicals & Consumables

The Commissioning Manager will be responsible for making allowance in his schedule and budget for the setup and staffing of site offices for the Commissioning Team. While most Operating companies will probably have policies, procedures and people assigned to look specifically at the site setup, the Commissioning Manager should ensure the following are taken into consideration, planned and budgeted for:

- Timing and cost of relocation from project offices to site(s)
- Physical office space needed
- Security arrangements
- Office equipment required – desks, chairs, filing cabinets, drawing racks, drawing folders, photocopiers, printers, plotters, scanners, etc Engage the Installation Contractor during FEED and DE.
- Apply the Completions Pyramid and the same PSCM to Subsea as well as Topsides.

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ffices, Logistics, Equipment, Chemicals & Consumables

- Replenishing office stationery and office supplies
- Storage space – site documentation
- IT networking and infrastructure
- Site 3G intranet
- Telephones, mobiles, tablets, radios, chargers, batteries, flashlights
- Resource plan
- PPE
- Site transportation and parking
- Office cleaning
- Canteen and eating arrangements locally

Commissioning & Start Up Workshop

ffices, Logistics, Equipment, Chemicals & Consumables

Commissioning consumables and equipment:

- Personnel Protective Equipment (PPE) – bags, gloves (all types), boots, hardhats, safety glasses, goggles, ear-defenders, ear-plugs, coveralls, harnesses, inertia reels, breathing apparatus
- Barrier tape, locks, chains, hooks, cable ties, Lock-Out Tag-Out labels,
- Label machine for making signs for "LIVE", Chemical, Hazard, Warning, Keep Out, etc
- System labelling
- Durable plastic wallets for signs and notices
- Hoses and connectors (air, water, steam, nitrogen)
- Test rigs, oil bath, calibration and test equipment
- Blind flanges and spectacle blinds, bolting and gaskets
- Gas sniffers and detectors (all types)
- Leak testing soap and bottles
- Sampling equipment and bottles

Commissioning & Start Up Workshop

ffices, Logistics, Equipment, Chemicals & Consumables

Specific considerations for international assignments are:

- Consular advice on the particular country
- Visas and / or Work Permits needed
- Medical examinations
- Healthcare provision in-country
- First Aid
- Emergency medical evacuation / repatriation
- Travel / Expense / Per Diem policy
- Car hire / site transportation / drivers / driver licensing
- Site accommodation and messing
- Working hours, overtime, rest days, rotations and leave
- Lone working policy
- Local culture, customs, climate, holidays and taxes
- Hiring local labor
- Insurances needed
- Training needed
- Salary, uplift, bonus

Procurement of Chemicals for Commissioning

Responsibility for procurement may not rest with the Commissioning Manager, but identifying what is needed and when, and which budget these items will come from, will be.

Treat the following as a guide:

- Oils, greases, lubricants
- Dyes, corrosion inhibitors
- Anti-foaming agents
- Heat exchanger fluids
- Refrigerants
- Hot oil (discussed later)
- Compressed air
- Nitrogen and other gases
- Filter media, desiccants
- Laboratory chemicals

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Procurement of Chemicals for Commissioning

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