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SUCCESSFUL PLANNING FOR OIL AND GAS MAINTENANCE WITH APPLICATION OF KEY FACTORS FOR TECHNICAL & COMMERCIAL SUCCESSFUL EXECUTION

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A B S T R A C T

Maintenance is an essential component of production success, as is the upkeep of oil and gas projects; the research outlines the tasks involved in oil field maintenance as well as the associated costs. a range of tasks including mobile equipment, scaffolding, hydroblasting, and fire apparatus. The study takes into account a number of significant factors that influence the process of determining how much oil and gas maintenance will cost. The report also covers decision-making processes related to shut-down and subcontractor selection. Included are various costing and planning techniques for spare parts and maintenance. Reliability, availability, safety factor, and spare parts management are among the important performance characteristics that are examined to assess the maintenance executor.

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1. INTRODUCTION

The Crude Gathering Centres & Refineries are Industrial production facilities, comprising of Pumps, compressors, heat exchangers, towers, refrigerators, heaters, water treatment Facilities, Gas Turbines, Gas Engines and Tanks (Olujobi et al,. 2022; Onuh et al., 2021). The objective is to increase the plant productivity and availability and uptime and eliminate unplanned interruptions and decrease shutdown periods & durations. Decrease the human accidents and eliminate major risks in hazardous areas working in tough environmental weather (Johnsen et al., 2020; Kas & Johnson, 2020). Final control of the cost and Expenditure and Barrel production cost (Kaiser, 2021; Yang et al., 2022). Contracting begins from the bidding stage where the contractor has to study the scope properly & formulate his winning and accurately calculated price, then mobilise the resources required for execution. After mobilization the contractor has to execute the different scope of maintenance activities scope, CMMS initiation and engineering, Maintenance Planning, Executing planned maintenance, Executing proactive maintenance and condition monitoring, Planning, Executing Planned maintenance ,Executing Proactive Maintenance & condition Monitoring, Planning & Executing Shutdowns & outages (AlHamouri et al., 2021; Velmurugan & Dhingra, 2021).

2. OBJECTIVES

The purpose of the study is to identify the client technical requirements in tender document and convert them to Commercial pricing inputs leading to a successful and profitable bid that will guarantee the proper execution of the Contract in a sensitive country economy main contributor which is crude production.

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The Process of preparing the successful bid comprises the following steps (Chen et al., 2021) (Figure 1):

a) Estimating the cost of new contracts for special maintenance services;
b) Estimation of the cost of Redesign and Management of Change MOC Mini-Projects;
c) Estimation of the Man-hours Cost;
d) Estimating the cost of Spares & Consumables;
e) Estimating the cost of overhauls and Major Shutdowns;
f) Estimation of the cost of general consumables;
g) Estimation of the Cost of Fuels and Oils;
h) Estimation of subcontracts & OEM support cost; and
i) The cost tracking of all maintenance activities like Man-hours PM to CM and PDM returns.



Figure 1. Cost for Maintenance process

3. THE PROCEDURE & MAIN COST INPUT FACTORS & EXECUTION PARAMETERS

One of the main factors are to identify the type of available equipment on site and determine its status in order to decide on the required Manpower resources for day to day activities up to shutdown execution, it is always beneficial to identify the Major Equipment and its expected Major overhauls during the contract tenure and the related cost to the same , usually we focus on Equipment like the trailing and Identify their Original Equipment Manufacturers "OEMS":

- Gas turbines (make: Ruston, General Electric, SOLAR Centaur, Dresser-Rand, Cobra, Kawasaki, Cooper Bessemer, Rolls-Royce, Nuo Pignone, GE);
- Generators: (make: Roll Royce Avon, Cummins, Caterpillar, Yammer; (gas / diesel driven);
- Gas compressors: (make: Cooper Bessemer, Thomassen, Dresser Clark, Solar, Kawasaki; Creuzot Loire - reciprocating and centrifugal types);
- Instrument Air Compressor: (make: Broom wade, Dresser Rand, Atlas Copco) ;
- Engines: (make: Cooper Bessemer, Cummins; gas / diesel driven);
- Pressure Vessels& De-salters & Dehydration Systems Scrubbers& Furnaces & Burners;
- Heat Exchangers : Shell, Tube, Plate type, Fin, Fan, etc.;
- Pumps: (make: Mather & Platt, Union, Dawson & Downie, David Brown, Worthington Simpson, Texteme, Marushichi, Nikkiso, Hayward Tyler, Lawrence, Gorham, Ebara, Union, Pacific, Milton Roy; Duty - crude, condensate, lube oil, waste oil, brackish water, down-hole water, cooling water, chemical feed, diesel, product, etc.);
- Tanks : (lube oil, diesel, water, crude oil, scale inhibitor and chemical storage);
- Oil and Gas & Water Manifolds;
- Water Treatment Plant;
- Water Injection Plants;
- Steam Generation Boilers.

The Contractor has to identify the Main Scope and the technical and managerial objective of the client in order to satisfy the required commercial & technical goals (Zid et al., 2020; Genc, 2023).

The contractor shall provide integrated maintenance management and full maintenance services for all Facilities in the Company's asset areas and continuously improve availability by providing cost effective maintenance and associated technical support services while ensuring the technical integrity of the facilities. The Company shall operate the facilities, while the Contractor shall provide full maintenance of the facilities by providing all management, supervision, personnel, material spares and equipment, plant, consumables, and facilities, in addition to Managing the services of the OEMS. While the Contractor shall work according to the Company's, program, technical standards and procedures, it shall however explore and recommend better maintenance strategies, standards and procedures focused on availability, integrity and safety of the Facilities. Any enhancements to the maintenance strategy and procedure proposed by the Contractor shall be rewarded through the KPI pattern explained latter I the project .

The following are the main technical activities to be executed by the contractor**:**

a) Repairs, testing, and/or modification to pipeline systems including crude flow lines, asbestos/cement pipelines, manifolds, GRP pipelines, valves, wellhead installations, tanks, vessels, pig launchers, and receivers
b) Steam cleaning and grit blasting, together with modifications, repairs, testing, and epoxy painting on internal surfaces of process vessels, pipes, and equipment as required.

c) Repair and maintenance of Gas Compressors , Gas Turbine & diesel engines, water pumps and mobile plants.
d) All instrumentation on the Gas Turbine, Gas compressor skids Gas/Diesel and Engines, Pumps, Instrument Air Compressor, Gas Scrubbers, Gas/Oil Separators / Dehydrating / Desalting system /Tanks, Vessels, Cooling Towers and Skids Auxiliaries.
e) Maintenance of DCS, PLC, SCADA including all the equipment associated with the fire & gas monitoring/protection system.
f) Electrical distribution systems in Fields, including substations, power transmission lines up to 66 KV, transformers, switchgears, underground cables, and feeders.
g) Scaffolding , Insulation , Civil Works, Heavy Railing Works

The estimate of the maintenance activities cost for different equipment:

a) The first step is to identify the scope and itemise it
b) The second step is to identify the required Manpower resources and required subcontractors & OEMs and formulate a communication with them to get a pre-bid quote to Include in the cost summary
c) The final step is to consolidate the cost

For example, for a Heater:

Tabel 1. Heater cost input resources with steps

Sl.	Job Step	Man-hours	Need Crane	Scaffold	Special	Remarks & Add. Req
1	Install Blinds	2		3000 Cum Meter required for 4 days	3000 NT Mt torque wrenches required for	Blinds 200$
2	Swing Elbows & Prepare Heater for Decoking	2				
3	Drop / Clean all Heater Burners / Reinstall	5				
4	Decode	2				Filters 300$
5	Open all access doors & Neutralize tubes OD by spraying	2				
6	Open all covers of the Ducts and Convection Section	5				
7	Dismantle all Burners assemblies	10	50Ton /3hrs			
8	Clean the weld joints of radiation & Conv. section tubes	5				
9	Clean &adjust all fuel gas and pilot burners	5				
10	Inspect	2				Inspection 500$
11	Refractory & Insultation Repair	10	50Ton /3hrs			Refractory 500$
12	Minor refractory work	2				
13	Install Burners assemblies	5				
14	Close up all covers & access doors & box up	5				
15	Remove Blinds & Clean area	5	50Ton /3hrs			

4. EXAMPLES OF SCOPE& RELEVANT PRICING INPUTS FOR DIFFERENT FIELD EQUIPMENT

a) Catalyst loading and unloading

The scope of work is:

- Handling of drums and bags for catalyst removal and reloading.
- Unloading of Catalyst; Supply of heavy duty plastic bags (of size 100cm x 150 cm x 140 microns) inside drums while dumping. Also, plastic bags shall be tied / closed using a nylon cable tie (12 inch x 14 inch or 300 mm x 6 mm wide).
- Screening and hand-picking and weighing of Catalyst - mechanical and manual as directed by the Company including vacuuming and cleaning of screens.
- Supply and installation of bucket hoppers for the lifting and loading ofcatalyst hoppers and chutes.
- Supply of the lifting crane of the required capacity and boom length including operator.
- Supply of forklifts, trucks including operators for movement of Catalyst during Catalyst loading and unloading operations.
- Reloading of catalyst: Sock loading and COP loading or any other method.
- Re-drumming of the spent catalyst including labeling and stenciling.
- Removal of catalyst drums and restoration of the work area to its previous condition.
- The scaffolding works

Cost inputs:

- The cost of the catalyst from the reactor supplier;
- The cost of manpower including Fitters, foreman, welders, fabricators, Foreman, supervisor, Machinist;
- The recue team is a main cost input as training is required from specialised companies http://www.angloco.co.uk/vehicles/rescue/;
- The vacuum machine and vacuum trucks are also Main input http://www.guzzler.com/;
- Cyclones, sifters, hoppers are specific Machine;

- Hydraulic large drills to break stuck gaskets is a main cost input;
- Bolt tensioners , Air Hoist , circulating pumps, etc. are cost input;
- Equipment such as compressors, trailers, welding machine, fork lift, cranes are one of the main cost inputs;
- Industrial elevators are Cost inputs;
- Drums to store catalyst http://alimakhek.com/Products/Industrial-Elevators/ALIMAK-SE-Ex;
- The cost of inspection is a main Cost.

b) Retubing of heat exchanger scope of work

The scope of the work consists of cleaning, tube removal, preparation works for retubing inspection, retubing work and hydrotest of Fin Fan coolers including repair work after tube bundle hydro-testing according to relevant TEMA standards and as instructed by the Company from time to time for the heat exchanger tube bundles / Finfan banks

Cost inputs:

- Supply of heat exchanger tube (Replacement) to be obtained from The suppliers and stocks.
- The Cost of Rental or Purchase of Hydro Test Pumps depending on the test Pressure from 10000 to 40000 Psi
- The cost of Retubing Tools and Tube Bundle Puller one of the main suppliers are Maus and Elliot and quotes could be obtained easily from them http://www.mausitalia.it/catalogs/http://www.elliott-tool.com/catalog/
- The cost of equipment to be utilized for repair Like Trailers to transfer bundles Forklift and Cranes (25 to 80 ton)
- The cost of manpower like fitters, machinists and Fabricators ,welders , Foreman and supervisors and Inspection Technician
- The Cost of Inspection and NDT Inspection like radiography and Eddy Current Test
- Usually the cost in The Market is Quoted as Trailing after contributing all Cost Inputs and will be per tube size (¼" or 1 2' up to 1 ½" and also the type of fixed plate or moving plate will have a cost input as the number of man hour consumed will be higher.)

c) Rehabilitation of plate type heat exchangers

The scope of services would normally include regasketing, replacing plates, minor repressing of plates, inspection, pressure testing, repairs to tie rods:

Cost inputs:

- Supply of the Heat Exchanger Plates from mainly Alpha Laval or any other supplier;
- The cost of Glue to Fix the Gaskets, The die penetrate from Magna Flux or Kemtel or similar;
- The Cost of Chemical Cleaner;
- The cost of circulating Chemical Cleaning Package comprising of tank and Circulating stainless steel pump for cleaning of Exchanger;
- The cost of manpower like fitters, machinists and Fabricators, welders, Foreman and supervisors and Inspection Technician;
- The cost of Hydrotest pump, usually a pneumatic driven Pump up to 2000 PSI;
- The cost of equipment to be utilized for repair Like trailers to transfer HX from site to workshop Forklift and Cranes (25 to 80 ton).

d) Valve Service Site Workshop

The scope is to perform the valve repair for all types of valves including globe, gate, butterfly, as well as calibration and testing of safety valves and control valves

Cost Input:

- The cost of The Land is a main input either purchase or rental
- The cost valve testing Benches depending on test type hydraulic of Pneumatic www.ventil.nlwww.rebotech.cn/ ,http://www.barbeetesters.com/
- The Cost of the Valve Lapping Machine http://www.lapmaster.com/
- The cost of a suitable drilling machine and lathe and shaper
- The cost of overhead crane up to 20 Ton
- The cost of fork lift and a Boom Truc " Truck with crane'
- The cost of compressor with Air dryer
- The lapping and cleaning consumables is a cost
- The cost of valves spares is a cost input
- The man power required from Valve technicians and welders ,machinist up to supervisors is a cost
- The cost of Audit by registering and regulatory bodies
- The cost of inspectors is an input

e) Scaffolding Operations

Scaffolding operations is a one of the main industry cost inputs , scaffolding is utilised in Shutdowns and new construction , also for inspections and painting , refractory works ……etc The scaffolding are different type like normal and suspended and confined space and form work for civil works

Cost Input:

- The cost of the material http://www.scaffoldingsales.co.uk/scaffold/
- The cost of manpower scaffolds and labors cost
- The storage yard where we store the scaffolding
- Refurbishment of defected material cost
- The Training and certification cost for scaffolder
- The scaffolding cost is usually sold in Cu Mt /Type or per rental cost of material all per month, also Manpower per hour rate could be a selling price for scaffolding services.

f) Tanks Maintenance

Tanks Maintenance include the scope of executing Tanks Cleaning, Desludging, Crude Recovery,

Inspection Painting, Fibre Glassing and repair the cost of repair is

Cost Input

- The cost of material including shell, roof, or bottom material;
- The cost of manpower including fitters, labors, welders, fabricators painters, sand blasters, and foreman up to supervisor;
- Cost of Equipment cost like trailers, cranes and forklifts, hydroblasting machines, painting machines, and sand blasting pots;
- Safety Equipment such as proper air breathing compressor and ventilation fans;
- The Cost of painting and fiber glassing Material from Jouton or Hemple;
- The welding and repair consumables are a factor;
- The crude desludging machine and oil recovery system; http://www.oreco.com/Solutions/Downloads.aspx;
- Waste disposal cost;
- The cost of floating roof seFals and cost of tanks nozzles and pipes replacement if required.

The cost of human resources activities

The Manpower is the most important & the most expensive portion of the tender and determine the correct numbers & Skills and salary and benefit levels required for both the day today Maintenance and the shutdown outages is a man success factor for the tender (Figure 2).

The following summarises the process of hiring & costs related to manpower

- Identify the required Job description for each project category, Including job overview, key accountabilities, required qualifications, education and experience, skills and knowledge, working conditions.
- Identify the salary benefits and contract duration.
- Arranging furnished accommodation facilities with levels as per grading structure and/ or individual employment contracts.
- Organising Catering Facilities for employees staying in the camps. The food served should be according to regional menus or a common menu. The regional menus generally available are Arab, Asian, East European, and Western.
- The Accommodation Code of ethics and regulations to be highlighted and circulated among employees to avoid discrepancies.
- Recreation and Playgrounds to be arranged for the employees spare time in those remote areas after duty.



Figure 2. Human resources costing input

The procurement and acquisition of tools &special services subcontracts

- Pre-qualification of suppliers and subcontractors based on Client recommended vendors list & earlier service providing & Supply success history. Selection criteria for evaluation, Categories lists, Vendor list for the project.
- Setting the Payment Terms to be in line with the main contract payments to avoid negative cash flows , including back-to-back payments.
- Procurement procedures of engineering services, spares, minor consumables, and Bulk items.
- Subcontract Administration and identifying the scope of subcontracts, liquidated damages , warranty retentions, guarantees, labour insurance, etc.

Equipment & vehicle rentals& purchase

- Identifying the Equipment and vehicle Specification as per the Contract specification.
- Conduct a buy/lease economic feasibility analysis and identify Purchase Lease.
- Establishing Site Maintenance Workshop for Mobile Equipment.
- The trailing are samples of Equipment specifications and Equipment & tools utilized in Oil and Gas Maintenance contract.

Table 2. Heavy Equipment list

1	Grit Blasting Machine with all Accessories
2	Airless Spray Paint System for Fast Curing Coating System with all accessories
3	Portable Breathing Air Compressor System & Safety Guard for Painting Works.
4	Mobile Air Compressor Rotary 750 CFM, 250 PSI
5	Saloon Car, 6 Cylinder & Pick-up, 1.5 Ton, 4 WD
6	5-Ton Truck with 5T Crane & Welding Truck

7	Mobile steam Generator
8	Bob Cat
9	Hydraulic crane , 25ton, 45Ton, 100 ton
10	Crude Vacuum Tankers & Water Tankers
11	Fork Lifts 3 tons
12	Transport Bus 60 Seat
13	Dump Trucks 40 cu Mt
14	Hydro jet machines 10,000 psi

Heavy Equipment list is presented in Table 2.

Spares and materials requirement matrix, control & storage

- The Spares Identification Scope of the maintenance. The project is the most challenging, we need to Identify:

1. The consumption rates the min/max ordering Qty, Calculate the ordering quantities.
2. Identifying the interchangeability between identical spares in different machines.
3. Identifying the stocking strategy (off-shelf or through stocking agreements with OEMs).
4. OEM spares & service agreements.
5. Refurbishment strategy, especially with expensive compressors, turbine spares.
6. The following are typical examples of spares Estimation for fire Fighting and HVAC Maintenance contracts. One is based on Tonnage of refrigeration spare consumption and the other depends on probability of spares utilization.

Maintenance cost estimate based on a TR norm is presented in Table 3 and Spares cost based on Consumption probability in Table 4.

Table 3. Maintenance cost estimate based on a TR norm (Tons Refrigeration)

Item	ITEM TOTAL QTY	UNIT	USD /TR/Year	Total Cost for ONE years	Total Cost for Five years
			USD		
ITEM NO. 1 CHILLED WATER SYSTEM (AIR COOLED PACKAGE CHILLER)	8200	TR	5	41,000	2,05,000
ITEM NO. 2 DX PACKAGE UNITS	2500	TR	2	5,000	25,000
ITEM NO. 3 DX PACKAGE UNITS FLAME PROOF	500	TR	2	1,000	5,000
ITEM NO. 4 DX SPLIT UNITS	2500	TR	2	5,000	25,000
ITEM NO. 5 DX SPLIT UNITS (FLAME PROOF)	250	TR	2	500	2,500
ITEM NO. 6 MINI SPLIT UNITS	1100	TR	2	2,200	11,000
ITEM NO. 7 WINDOW UNITS	2300	TR	2	4,600	23,000

Table 4. Spares cost based on Consumption probability

Equipment Name	Qty	Spares	Expectation	Freq. /year	Estimated No. per system	Total Qty.	Unit rate for spare materials	Total for 5 Years
Escape Masks	208	Face mask 24 KDx10% of masks	0.50	1.00	1.00	104	24.00	12,480
		Filter Catridge	0.50	1.00	1.00	104	6.80	3,536
		Training by dragger (200kdx2)	1.00	0.20	1.00	42	1.92	400
		Certification 5Kd per year	0.70	1.00	1.00	146	5.00	3,640
							Sub Total:	20,056
Breathing Apparatus w/cylinder	176	Face mask 49 KDx10% of masks	0.50	1.00	1.00	88	49.00	4,312
		Certification 5Kd per year	0.70	1.00	1.00	123	5.00	616
							Sub Total:	4,928.000

5. OPERATIONS AND SHIFTS & UTILISATION OF TPM METHODS TO ENHANCE MAINTENANCE OUTPUTS & COST CONTROL

The cost of overtime and work during the holidays and the load sharing of manpower (Figure 3) is crucial portion of winning tender especially in work circumstance of oil fields, having round clock operations, and to maximize the utilization of the work force and considering remoteness of the fields and the high caliber required for the dealing with those systems, it is a common trend to implement the TPM or total productive maintenance concepts during the Shift and accordingly the following manipulation to be taken:

- Maintenance Instrument Technicians will be involved directly in local controllers operation including PLCS.
- Maint. Mechanics should be operating the Utility & Instrument Air compression packages & Nitrogen Generation packages.& Gas Turbines Packages.
- Maint. Fitters will be involved in valve closing & opening.
- Maint. Inst. Foreman will be involved in DCS & SCADA operation.

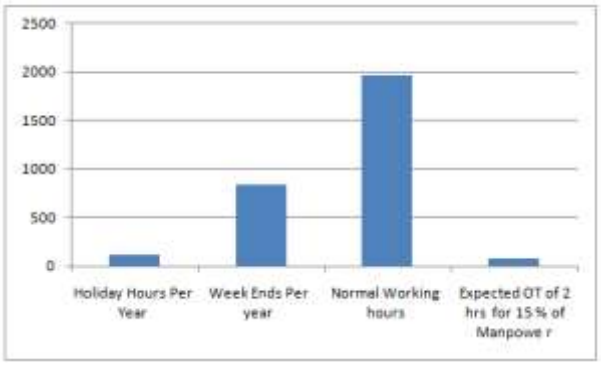


Figure-3. Expected extra hours due to holidays & Week ends work

Human resource management, training& promotion



Figure 4. Manpower training cycle

The cost of Training Has to be Included as having around 1000 Workers from labour up to the engineer level in all disciplines from planning, turning-around execution, mechanical, electrical, instrumentation maintenance, condition monitoring, materials handling and cost control for a contract period of 6 – 7 years requires attention to manpower training , appraisal and promotion. through the following:

- Safety training programs are conducted monthly
- On-the-job training and after-duty technical training programs to upgrade manpower from labour to fitter to technician to Supervisor category, the technical training is done through a criteria that defines the knowledge area required and on site exams and trade tests take place continuously for upgrade.
- Incentive bonuses are issued especially during the turnaround periods.
- Yearly appraisals and evaluations are conducted to identify performance and methods of the past year performance & methods to excel & recommendations for improvement.
- Equal opportunity and a nondiscriminatory code of ethics is implemented to avoid ethnic or cast problems between workers from more than 20 countries.

Manpower training cycle is presented on Figure 4.

Condition monitoring as a typical example of the benefit of training

To run an oil Field the implementation of a condition Monitoring System having different variations of prediction tools is a must and the difficulty is impeded by two factors , first is the lack of experience of Technicians having caliber in vibration data collection and analysis and Thermography , Borescope inspection , Ultra sound and Reciprocating Reciptrap analysis In addition to Oil analysis . The second is there is no available Subcontractors to execute the subject job, accordingly during the Mobilization Stage it is a Must to have the training as part of the supply of the condition Monitoring tools the subject investment will decrease the cost of Predictive maintenance.

CMMS engineering & implementation



Figure 5. CMMS building & Management activities

The contractor has to get acquainted to the company CMMS and suggest improvements as the majority of the KPI calculations will be extracted from CMMS (Figure 5). The contractor has to include the cost of a team comprising CMM specialists for at least 3-4 months during the Mobilization period to account for:

- Review the maintenance history and other information, and recommend maintenance strategies and develop plans to achieve KPI targets.
- Review and update the existing maintenance procedures, frequencies, resources, job scopes, special tools, and spare requirements. All proposed revisions or additions to these procedures and the Company's CMMS shall be subject to prior approval by the Company before incorporation.

The following are the stages of executing the system review &Maintenance Engineering:

- Technical Data Gathering;
- Equipment List and classification;
- Review of comprehensive maintenance / inspection plan;
- Fitting the main characteristics of the maintenance management software package to be suitable for the running maintenance conditions;
- Check local area network and modify based on contract execution strategy;
- Integration with Condition monitoring & Inspection systems.

The budgeting and estimation for shutdown

Shutdown is the biggest and most expensive fast track maintenance project that should be properly planned and budgeted below.

1. Before going to shut down the contractor must explore the following and test the alternative of performing maintenance during normal working days and decreasing the shutdown period, Decreasing shutdown Period is one of the main KPIs (Figure 6).

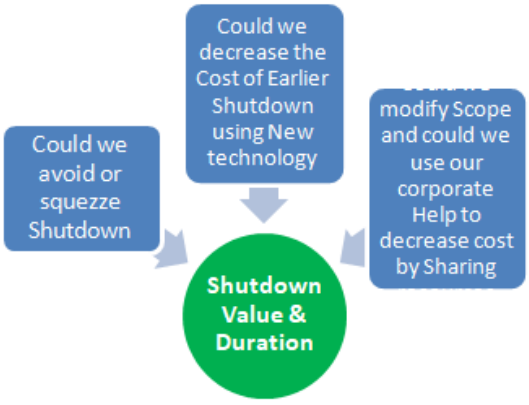


Figure 6. Shutdown decision plan

2. The Shutdown Team Is the Main Cost "Manpower cost ";
3. Cost of Subcontractors & Supply Chain during Shutdown (Figure 7);

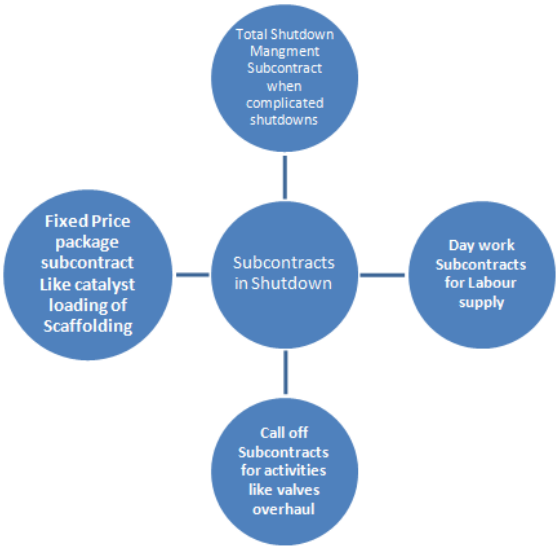


Figure 7. Shutdown decision plan for subcontractors



Figure 8. Closed shutdown report

4. Closing the shutdown and consolidating Shutdown report is very important for next shutdown estimation (Figure 8).

6. THE CONTRACT KEY PERFORMANCE INDICATORS AND INCENTIVES

The achievement of key performance Indicators & Gaining its relevant incentive is one of the main targets of the contractor and the KPIs of the trailing is some of the maintenance contracts KPI

- Total Maintenance Cost as a percentage of Replacement Asset Value;
- Corrective Maintenance Cost Compared to Preventive Maintenance Cost;
- Condition-Based Maintenance Cost compared to Preventive Maintenance Cost;
- Maintenance Shutdown Costs& Duration Reduction;
- Actual cost to Planning Estimate;
- Actual Hours to Planning Estimate;
- Indirect contractor maintenance personnel cost compared to Internal Maintenance Employee Cost;
- Overtime Maintenance Cost;
- Safety improvement & Reduction of accidents & Injuries & first aid.

Example KPI calculation percentage of overdue work orders

The % overdue work order for each asset area is calculated each month, based on the information available in the Company's "Material & Maintenance Management System" (MMMS) and the importance factors, detailed here.

Work Order Priority Importance Factor
Corrective Maintenance Priority 1 1.0
Corrective Maintenance Priority 2 0.9

Corrective Maintenance Priority 3 0.8
Corrective Maintenance Priority 4 0.2
Automated Work Order 1.0
(3 monthly / 6 monthly / Annual)
Auto-Generated Work Order (the rest) 0.5
Method of Calculation

$$\% \text{ Overdue Work Orders} = \left[\frac{a + 0.9b + 0.8c + 0.2d + e + 0.5f}{A + B + C + D + E + F} \right] X100$$

Where
A = Number of Work Orders for Corrective Maintenance Priority 1
B = number of corrective maintenance priority 2 Work Orders
C = number of work orders of corrective maintenance priority3
D= Number of Correctional Maintenance Priority 4 Work Orders
E= Number of Autogenerated Work Order (3 monthly / 6 monthly / Annual)
F = number of autogenerated work orders (the rest)
a= Number of Priority 1 Work Orders Overdue
b= Number of corrective maintenance priority 2 Work Orders Overdue
c= Number of Corrective Maintenance Priority 3 Work Orders Overdue
d= Number of corrective maintenance priority 4 Work Orders Overdue
e= Number of Auto generated Work Order (3 Monthly / 6 monthly / Annual) Overdue
f= Number of Auto Generated Work Order (the rest) Overdue

The target is 3 % if below this target, a bonus maximum of 200,0000 USD will be paid yearly based on the following equation: KPI incentive =200,000 X (3 – Achieved % overdue work orders)/3

Monthly Safety Inspection Checklist is presented on Figure 5.

The cost of personnel protective equipment and safety officers and license renewal and OHSAS audits & regulatory laws has to be included to avoid the loose in safety penalties and keeping the company image in the market

The OHSAS 18001 safety procedures are applied including: Incident Reporting & Investigation &Emergency Plan & Health, Safety & Environment Training & Disciplinary Procedure & First Aid & Safety Inspection & Safety Inspection & Welding, Cutting & Hot Work & Fire Prevention Programme & Confined Space & Fall Protection & Scaffolding & Lifting and Rigging Operations & Excavation & Hazard Communication & Housekeeping & Compressed Gas Cylinders & Abrasive Wheels & Manual Handling & Abrasive Blasting & Painting & Traffic & Road Works & Hearing Conservation Programme & Safety Motivation Programme & Safety Guidelines for Shutdown Work in Process Plants.

Table 5. Monthly Safety Inspection Checklist

Monthly Safety Inspections Track							
Index	**Gathering Center**	**Well Head**	**Booster station**	**Water facilities**	**B-Shift**	**C-Shift**	**Shutdown Team**
Site Walk-around Safety Inspection Checklist	□	□	□	□	□	□	□
Equipment Inspection Checklist-Crane/Mobile Elevated Working Platforms	N/A	N/A	N/A	N/A	□	N/A	□
Equipment Inspection - Industrial Powered Trucks	N/A	□	N/A	N/A	□	N/A	□
Generator/Compressor/Welding Machine - Safety Inspection	□	□	N/A	N/A	□	N/A	N/A
Electrical Inspection Record	□	□	□	□	□	□	□
Hand & Power Tools Inspection Checklist	□	□	□	□	□	□	□
Ladder Inspection Record	□	□	□	N/A	□	□	□
Rigging Equipment Inspection Record	□	□	□	N/A	□	N/A	□
Full Body Harness and Lanyard Inspection Record	□	□	□	N/A	□	□	□
Fire Fighting Equipment Monthly Inspection Record	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fire Extinguisher Monthly Inspection Report	□	□	□	□	□	□	□
Foreman's Weekly Safety Inspection Checklist	□	□	□	□	□	□	□
Supervisor/Foreman's Pre-Task Safety Briefing & Inspection	□	□	□	□	□	□	□
Daily Safety Inspection Checklist	□	□	□	N/A	□	□	□
Daily Safety Log/Concern/Observation	□	□	□	N/A	□	□	□

Finally, the total cost is incorporated in one single sheet is presented in Table 6.

Table 6. Total shutdown cost

Category	Description	Value $
1	Materials & Tools & Special Tools	
2	Sub-Contract Items	
	Insulation & Painting Scaffolding	
	Catalyst Loading	
	Inspection & Condition Monitoring	
	Special Welding & Fabrication	
	Refractory Works	
3	Manual Manpower (Fitters & Technicians)	
	Salaries & Wages - Overtime for Manual Manpower	
4	Construction Equipment & Vehicles	
5	Indirect Costs:	
	Bank Interest & Guarantees & Insurance	
6	Non Manual Manpower	
9.96	Overheads & Contingency	
7	Management Overheads	
	Final Price:	

Summary of cost percentage items is presented on the figure 9.

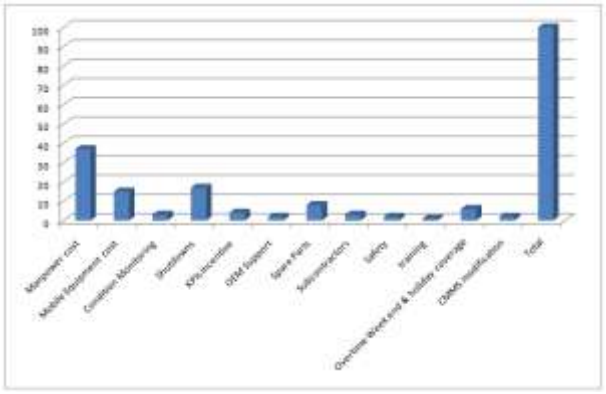


Figure 9. Maintenance cost percentages by category

7. CONCLUSION

Maintenance of oil and gas costing and management planning is a detailed procedure that requires good costing and planning and a techno-commercial background. The project manager must initially plan all required resources from manpower, spares, equipment, and special services. The scheduling and mobilisation should be planned properly and the cost of all factors should be taken into account and accordingly the final project techno-commercial plan of the project is concluded, discussed and shared with the team. The key performance indicators, mainly safety, should be recorded and monitored during execution. The standards and suppliers recommendation & OSHA rules should be thoroughly implemented to avoid any catastrophe. The cost of the manpower forms around 40% of the project cost, accordingly is the most important cost input and requires special care from human resources to guarantee continuous presence of manpower and avoid their resignation. Heavy equipment could reach 25% of the work cost and requires special handling and proper calculation of the load and requirements. Scaffolding also is a major cost input, especially in shutdowns. Gas turbines and power plants have a huge original equipment manufacturer cost that could reach 80%; accordingly, careful contracting and agreements with OEMs should be taken care of spare parts is an important factor and their percentage varies based on the plant age, it is always good practice to implement a KPI monitoring procedure to spares consumption in order to have a good vision of economical plant operations. Renovating is a very important method to decrease the strategic spare expenditure. The cost of the subcontractor should be an outcome of balance between outsourcing and investing in special equipment and tools. The shutdown portion of the project should be priced independently and accurately. The maintenance project costing is a challenge for the maintenance engineer and should be aware of all cost inputs and implement the same in a careful manner to achieve the best cost.

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