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Title:

Applicability of Terotechnology in Planning, Designing and Construction of HIV/AIDS management facilities-Case study on the Oxygen Generation plant at Moi Teaching & Referral Hospital

By

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ABSTRACT

- Kenya like other countries in Africa has witness increased cases of HIV/Aids patients; Moi Teaching & Referral Hospital is not a exception. The Hospital has done more on the management of the patients both at the institution and in the neighboring institution. With the inception of Academic Model for The Prevention of Hiv/Aids-AMPATH which is the main a research centres for HIV/Aids. MTRH has gone further than this and Design and constructed a Plant house for the Oxygen Plant. This was brought about by the fact that many HIV/Aids patients have TB and oxygen is very vital for the survival of these patients while admitted in MTRH. The consumption of oxygen has been on the increase due to this and the Hospital resorted to procure its own oxygen plant for ease of maintenance of the patients hence the basis of this paper.
- This paper explores the use of LCCA variously known as terotechnology, in the planning, Design and Construction of HIV/Aids management facilities. It reviews literature on appropriateness of terotechnology as a tool for planning, designing and construction of the facilities as can be used in other projects too.
- The paper uses data generated from an oxygen generating plant to exemplify procedures and applicability of terotechnology in Planning, Designing and Construction of HIV/Aids management facilities. It concludes that terotechnology is applicable in planning, Designing and Construction of HIV/Aids facilities as in the case study at Moi Teaching & Referral Hospital, which planned, Design and procured the Oxygen Generating Plant

Introduction

- The Moi Teaching and Referral Hospital is
- Located in Eldoret town of Uasin Gishu District.
- Covers an area of 27.04 hectors of land.
- Started as a Native Cortege Hospital to the National Referral Hospital.
- In 1917 it had a bed capacity of 60 beds basically to cater for Africans health needs.
- By 1963 the bed capacity had rose to 125 beds with an Amenity wards to carter for Asians.
- In 1986, the Nyayo Wards was constructed which increased the bed capacity to 324 beds.
- Currently with the acquisition of Memorial Hospital and opening of the Amenity A & B-now called the private wings, the bed capacity stands at 550

1.2 Background Information

- Riggs, (1982) defines Life cycle cost analysis as the costs of a system or a product calculated over its entire life span. From its very beginnings with the US military in the 1960s, organizations have considered LCC analysis a valuable tool when making investment decisions. LCC refers to all costs associated with acquisition and ownership of a product or system over its full life. LCC evaluation determines the differences in the net present value of competing options and helps identify the option that is the best value for the owner, (Wolter and Benjamin, 1991)
- The cumulative costs from these aftermarket activities often significantly exceed the initial purchase price of the unit. Today, as rotating equipment operators begin to realize that the cost of maintaining a project or machine far exceeds the initial acquisition cost, LCC analysis gives them an understanding of the total cost likely to be incurred during the life of a project or a particular piece of equipment.
- Life Cycle Cost Analysis is an essential design process for controlling the initial and the future cost of building ownership. LCCA can be used to evaluate the cost of a full range of projects, from an entire site complex to a specific organization system component.

Oxygen generation plant

- There are two basic oxygen generation systems:
- The traditional cryogenic air separation (CAS) process for the large size plants.
- The pressure-swing adsorption (PSA) process for smaller and more common plant sizes (Wang & Shammas,2006)

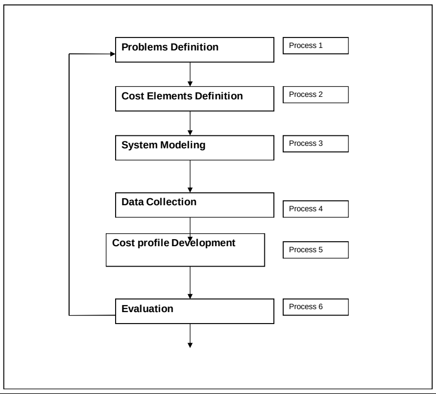
Cryogenic Air Separation (CAS)

- According to Wang & Shammas, (2006)
- CAS process involves the liquefaction of air followed by fractional distillation to separate it into its components (mainly nitrogen and oxygen).
- Air is first filtered and then compressed.
- It is then fed to the reversing beat exchangers, which perform the dual function of cooling and removing the water vapor and carbon dioxide by freezing these mixtures out onto the exchanger surfaces.
- This process is accomplished by periodically switching or "reversing" the feed air and the waste nitrogen streams through identical passes of the exchangers to regenerate their water vapor and carbon dioxide removal capacity.
- The air is next processed through "cold end gel traps." which are absorbent beds, which remove the final traces of carbon dioxide as well as most of the hydrocarbons from the feed air. It is then divided into two streams, one of which feeds directly to the "lower column" of the distillation unit and the other is returned to the reversing heat exchangers and partially warmed to provide the required temperature difference across the exchanger.
- This second stream is then passed through an expansion turbine and fed into the "upper column" of the distillation unit. An oxygen – rich liquid exist from the bottom of the "lower column" and the liquid nitrogen from the top.
- Both streams are then sub-cooled and transferred to the upper column. In this column the descending liquid phase becomes progressively richer in oxygen until oxygen is collected as a product in the condenser re-boiler.
- This oxygen stream is continually re-circulated through an adsorption trap to remove all possible residual traces of hydrocarbons. The nitrogen exists from the top portion of the "upper column" and its beat is exchanged with the oxygen product to recover all available refrigeration and to regenerate the reversing heat exchangers as discussed earlier.

The PSA system

- The PSA system Wang & Shammas, (2006)
- It uses two (or more) adsorbent vessels to provide a continuous and constant flow of oxygen gas.
- The system requires a source of dry, filtered air to produce pure oxygen that is 85 – 95% pure.
- PSA units operate on a demand basis and produce oxygen only when needed.
- Compressed air flows through a pressure vessel packed with a granular material that functions as a molecular sieve. The sieve material is usually *clinoptilolite,* one of several types of naturally occurring zeolites.
- The packing material selectively absorbs nitrogen from the air providing an oxygen enriched gas.
- When the nitrogen absorption capacity of the filter bed is reached, the column is depressurized, nitrogen is removed, and the bed is subsequently reused.
- The enriched oxygen flow represents about 5% of the required air flow (Watten, 1991).

LCC Methodology



Life Cycle Cost Analysis process

Problems definition

Life Cycle Cost analysis starts from the process "Problems definition" and the other five processes are iteratively carried out one after the completion of the preceding one.

Scope definition

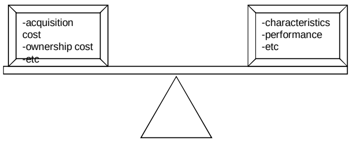
The first step of any LCC analysis should be to clearly the problems and the scope of work.

The term "scope" means aspects, such as the scope of program phases to be modeled, the scope of equipment to be modeled, the scope of activities to be modeled, etc.

A clear definition of the scope is necessary to get a clear definition of the cost elements which are the basis for predicting the total LCC.

Analysis and recommendation criteria definition

- The Analysis and recommendation is the last process but should also be defined in the first process of Problem Definition-Process 1. The criteria should encompass not only the total cost, but also system performance and effectiveness as show in Fig.1.



According to Lydersen and Aaroe (1989) the decisions concerning "Cost" of a system should not be made independently: it should be made with considering "Cost", together with "Effectiveness" of the system as well. The effectiveness may comprise system characteristics, like production capacity, product quality etc., and also system performance characteristics, like system availability, the safety integrity level of shutdown systems, etc.

Cost breakdown structure (CBS) development

- It is important to identify all cost items, or the so-called "cost elements", that shall considerably influence the total LCC of the system.
- Cost breakdown structure shall be developed by defining items along three independent axes, which are "Life cycle phase", "Product/work breakdown structure", and "Cost categories" as illustrated Fig.2.

System modeling- Process 3

One has to make a model to quantify the cost elements encompassed in a LCC analysis.

To make a model means to find appropriate relations among input parameters and the cost elements. If any existing models appropriate for estimating of cost elements are available, we shall utilize the models to estimate the cost elements. If not, we shall be forced to establish new models for the cost elements.

In general, a system should be modeled from many viewpoints such as availability, maintainability, logistics, risk, human error in the system, etc. However, according to Clarke, J.D (1990) it is supposed that the availability and the maintainability are the most significant cost drivers in LCC analysis,

Availability

- Hurst, (1995) give us a model to us in calculating availability which is a standard way of calculating availability of many equipment which translates to- the availability of a repairable component is approximated by dividing the mean time to failure (MTTF) by the MTTF plus mean time to repair (MTTR) as expressed in Eq. (1), if "as good as new" after repair and no trends in the time to failure are assumed.
- = *MTTF*
- *MTT+FMTTR*
- = *MTTF*
- *MTBF*
- Where MTBF represents the mean time between failures, which is equal to MTTF+MTTR illustrated in fig.3.

Maintenance and inspection modeling

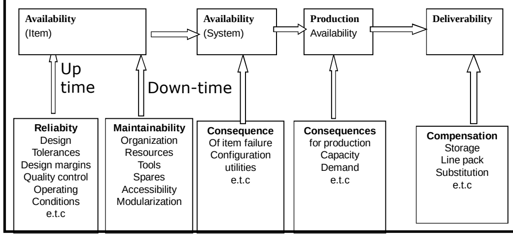
- The frequency of maintenance or inspection considerably influences on both the "availability performance" and the "operating cost", i.e., man-hour cost, spare part consumption cost.
- Maintenance may be categorized in two main types: "Corrective maintenance" and "Preventive maintenance".
- Sometimes, a preventive maintenance based on condition monitoring by modern measurement and signal-processing techniques is called "Predictive maintenance".

Logistics modeling

- According to Prescott (1990), Logistics may be measured by indexes like "Logistics support" and "Supportability".
- The following eight elements may be considered in the analysis of logistic support, Blanchard, B. S (1994).These are:-
  - (1) Maintenance personnel
  - (2) Training and training support
  - (3) Supply support
  - (4) Support equipment
  - (5) Computer resources
  - (6) Packing, handling, storage, and transportation
  - (7) Maintenance facilities
  - (8) Technical data, information systems

Production regularity modeling

- Regularity may be defined as a term used to describe how a system is capable of meeting demand for deliveries or performance



Production regularity modeling

- "System availability" is the ratio of a period of up time to a period of operating time.
- "Production availability", defined as the ratio of production to planned production, could be simple measure of regularity.
- It is, however, possible to consider not only the production system, but also buffer tanks or any other back-up systems in case that the production system is down.
- Therefore, regularity may preferably be measured by a factor called "deliverability" defined as the ratio of deliveries to planned deliveries over a specified period of time, when the effect of compensating elements such as substitution from other producers and downstream buffer storage is include

Production regularity modeling

- For instance, in an actual regularity analysis, the following three measures may be applicable as measures of "production availability".
- (1) Production availability: The ratio of real gas production to contracted production volumes. The production availability may be expressed per year or as a life cycle average.
- (2) Demand production availability: The percentage of time when the system is capable of producing 100% of the contracted production volume.
- (3) On-stream production availability: The percentage of time the production rate in the system is larger than zero. This measurement reflects the risk of having a total production shutdown.

Data collections

- Accuracy of input data is crucial to improve the certainty of the LCC prediction. As for data collection, it is required to identify the requirements of input data and to access reliable data sources related to the LCC analysis. If actual data are available to quantify cost elements in a Cost Breakdown Structure, each cost element may be quantified by directly applying the collected actual data to the model of LCC. If actual data are not available, the cost elements relevant to the non-available data may be estimated. Most of the data though is sourced from the records available at the Hospital. The records of the oxygen consumption, tender document and the relevant technical datasheet have been used in this analysis.

Reference

- Aaroe, R. (1989). Reliability prediction handbook, computer-based process safety systems, SINTEF Safety and Reliability.
- Blanchard, B.S. and Fabrycky, W.J.: Systems Engineering and Analysis 3rd Edition, Prentice Hall International Series in Industrial and Systems Engineering, (1998)
- Blanchard, B. S. (1995). Maintainability, John Wiley & Sons, Inc.,
- Blanchard B. S. (1992). Logistics Engineering and Management (4th Ed). Prentice-Hall International Series in Industrial and Systems Engineering.
- Clarke, J. D. (1990). Life Cycle Cost: An examination of its application in the United States, and potential for use in the Australian defense forces, Thesis of M.S, Naval Postgraduate School.
- Dangel, R. (1969). Integrated Logistic Support (ILS) Implementation in the Naval Ship System Command, ASE 6th annual technical symposium (pp. 1-25).
- Fabrycky, W.J. and Blanchard, B. (1991). Life-cycle cost and economic analysis, Prentice Hall International Series in Industrial and Systems Engineering.
- Garin, T A. (1991). A Preferred Spare Decision Support System Incorporating a Lie Cycle Cost Model, Thesis of M.S, Faculty of the School of Engineering of the Air Force Institute of Technology, Air University,
- Hurst, D.J. (1995). Operational Availability Modeling from Risk and Impact Analysis, Proceedings of IEEE Annual Reliability and Maintainability Symposium 1995 (pp. 391-396)
- IEC60300-3-3: Life cycle costing
- IEC 60300-3-11-Reliability Centered Management
- Lydersen, S., and Aaroe, R. (1989). Life cycle cost prediction handbook, computer-based process safety systems, SINTEF Safety and Reliability,
- Myrick, A. L. (1989). Sparing Analysis – A Multi-Use Plan, Proceedings of IEEE Annual Reliability and Maintainability Symposium 1989 (pp. 296-300)
- NORSOK O-CR-001: Life cycle cost for systems and equipment
- NORSOK O-CR-002: Life cycle cost for production facility
- Prescott, N.J. (1995). Equipment Life: Can We Afford To Extend It?, Proceedings of IEEE Annual Reliability and Maintainability Symposium 1995 (pp. 529-535).
- Ondieki C. M. M (2004). Telotechnology
- Raushand, M. (1998). Reliability centered maintenance, Reliability Engineering and System Safety, 60, (pp. 121-132).

Thank you