Asset Utilization: A Metric for Focusing Reliability Efforts

by Richard Ellis
The RE Group
Pearland, Texas

Seventh International Conference on Process Plant Reliability

Marriott Houston Westside
Houston, Texas

October 25-30, 1998

Organized by
Gulf Publishing Company
and
HYDROCARBON PROCESSING

Asset Utilization: A Metric for Focusing Reliability Efforts

Richard P. Ellis
The RE Group
P.O. Box 1436
Pearland, Texas 77588-1436

Phone: (281) 652-0528
Fax: (281) 652-0529
E-mail: richard@armic.com

In today's cost-cutting, globally competitive market, there is perhaps no more critical area in terms of plant profitability than asset utilization (AU). Asset utilization is a tool focused on uncovering your hidden plant by measuring the difference between what the asset is capable of producing and what it actually produces. This difference is referred to as the "opportunity gap."

But an effective asset utilization program does more than just identify opportunity gaps; it also documents the causes of the gaps. Once documented, the causes can be charted based on their impact to the business, and reliability efforts can then be focused on systematic elimination of the causes.

This paper will explore the concept of asset utilization in more detail by addressing the four components: people, processes, technology and information, that comprise effective asset utilization programs. Examples of asset utilization data from different plants will also be presented to illustrate the power of this simple measurement.

Asset Utilization Defined

Before addressing the components that comprise an asset utilization program, it is important to establish a common point of reference regarding what exactly is meant by asset utilization. The concept behind asset utilization as discussed in this paper is often disguised behind terms such as uptime, maximum equipment uptime, minimum equipment downtime, and maximum equipment capacity. But regardless of how it is referenced, the purpose behind this measurement is the same: to measure the difference between what an asset is capable of producing and what it actually produces, and with this data to calculate the "opportunity gap." Properly measured and understood, asset utilization, or more correctly stated, the opportunity gap, can be used as a metric for focusing reliability efforts.

While there is no accepted industry definition for asset utilization, the definitions used by most companies look something like the following:

> The ratio of actual output to the output that could be achieved if a plant ran at its maximum capacity for 365 days per year while producing 100% quality product.

Definition 1 - Asset Utilization

From this definition, we see that at the most basic level, implementing an asset utilization program requires the capture of only two pieces of data: actual output and maximum capacity. With this information, it is then possible to calculate asset utilization using the Equation 1, and the opportunity gap using Equation 2.

AU = (actual output / maximum capacity) *100

Equation 1 - Asset Utilization

Opportunity Gap = maximum capacity - actual output

Equation 2 - Opportunity Gap

The following table illustrates a simple form for capturing asset utilization data at the level of detail discussed thus far.

Date	Maximum Asset Capacity [tons/day]	Actual Output [tons/day]	Asset Utilization [%]	Opportunity Gap [tons]
1-Jan-98	1211	1206	99.6	5
2-Jan-98	1211	1204	99.4	7
3-Jan-98	1211	1199	99.0	12
4-Jan-98	1211	898	74.2	313
5-Jan-98	1211	1188	98.1	23
			Total	360

Table 1 - Basic Asset Utilization Data

Now that we know what is meant by asset utilization and opportunity gap, and know how to calculate them, what does the information tell us? Well at this level of detail, not much.

We do know that the largest opportunity gap and correspondingly the lowest asset utilization occurred on January 4, 1998. We also know that in the first five days of the month, the opportunity gap for this plant totaled 360 tons. However, depending on the profit margin of the product being produced 360 tons may or may not be significant. The answer to that question requires additional knowledge about the business. While we do know a few facts, without additional information these measurements just tell us how we are doing in a relative sense, i.e. is our level of asset utilization good or bad. What we do not know is where to focus improvement efforts.

As stated previously, for an asset utilization program to be effective, it has to do more than just measure the difference between what an asset is capable of producing and what it actually produces. An effective asset utilization program must include a process for documenting the level(s) at which losses occur and the cause(s) of the losses. Once documented, the causes for the losses can be charted based on the impact to the business, and reliability efforts focused on eliminating the cause(s). At that point we can move from a measurement that just tells us where we are in a relative sense, to a measurement that provides direction.

So far we have established a common definition of asset utilization and derived an equation for calculating it and are beginning to learn the elements that make up an effective asset utilization program. In the next section, we will continue to develop our understanding by examining the elements that comprise an asset utilization model.

Asset Utilization Models

For asset utilization data to be useful to multiple levels of an organization, it is necessary to provide the ability to summarize, or roll-up the data captured by the program to various levels. This need drives the requirement to create levels of measurement. The reason for this is that the level of detail required by a manager is different than say the level of detail needed by a reliability engineer who is challenged with solving the problem.

The following provides an overview of the different levels that an asset utilization model may contain, as well as examples of causes of losses.

Levels of Measurement

Industry
At a corporate level, management of diversified companies may wish to develop AU models by industry segment such as: agriculture, chemical, food, petroleum or power. This 60,000 foot level can give them insight into how each of the segments is operating, and quantify how significant the opportunities are within each respective segment. Sample industry segments are displayed in Table 2.

agricultural	oil	power
chemical	paper	textiles
food	petroleum	
mining	pharmaceutical	

Table 2 - Industry Segments for AU Models

Business
A business level asset utilization model is another corporate level model where the names used to segment the businesses are unique to each company. Table 3 illustrates how three companies, the Amoco Corporation (1), Exxon Chemicals (2) and Dow Chemical (3) might chose to track asset utilization based on how they have organized there respective companies into business segments.

Amoco Corporation	**Exxon Chemicals**	**Dow Chemical**
Exploration and Production	Olefins	Chemicals
Petroleum Products	Aromatics	Plastics
Chemicals	Polypropylene	Agricultural Products

Table 3 - Business Levels for AU Models

Site or Division
A site or division based model sorts asset utilization measurements based on geography. For example, Exxon Chemicals organizes their plants using the following geographic areas: North America, Central and South America, Europe, Middle East and Africa, and Asia-Pacific (2), while Dow Chemical organizes their plants into just three geographic regions: U.S., Europe and an "Other" category (3).

Plant
The plant level is the most fundamental level of any asset utilization model and is typically the level at which most asset utilization programs begin. In the chemical industry, plant names are typically based on the products they produce, e.g. ethylene, polyethylene, benzene, etc., and may also be numbered (Benzene

II) when a company has more than one plant producing the same product. While the petroleum industry may name their plants according to physical location, as in Baton Rouge Refinery.

Unit Operations or Process Areas
Most plants are sub-divided into unit operations or process areas for the purpose of assigning resources. Typical names for these areas might be furnace area, physical plant 1, north process area, and storage area. The names of these areas can provide another reporting level for measuring the impact of asset utilization losses.

System
By system, we are referring to a process system, such as that which is developed when designing a new plant, or found in manuals used to train new employees. Table 4 provides examples of systems that might be included in an asset utilization model.

steam	condensate	chlorine
nitrogen	oxygen	fuel gas
plant air	chilled water	potable water
boiler feedwater	cooling water	refrigeration

Table 4 - Systems Levels for AU Models

Note: two good sources of information for defining systems in a plant are the piping and instrumentation diagrams (P&ID's), and the pipe specifications.

Other levels for asset utilization models exist, but won't be addressed here. What is important to understand is that levels of measurement exist, and that ultimately, the numbers of levels that exist in a company's asset utilization model are a function of the two things. First, is at what level of the organization the asset utilization program being driven? Secondly are the goals and objectives of the plant or organization. Always bear in mind that there is no "right" model or answer. When designing an asset utilization model, regardless of the level you are working, remember that you are better off creating a model, implementing it and driving towards results than you are wasting time arguing over what is right. Maintain a bias for action.

Causes of Loss

Knowing where losses occurred, i.e. the levels of measurement, is fine for reporting purposes, but it is inadequate in helping to understand why the losses occurred. To understand why, and identify solutions that will prevent recurrence, requires an additional level of detail. This additional level of detail will be referred to as "causes of loss." The causes of loss represent the starting point for focusing reliability improvement efforts because they provide the means to help define the problem, and defining the problem is the first step involved in effective problem solving.

Not all lost production incidents are caused by, or within the control of the plant. For this reason, every asset utilization model must include categories to which the losses caused by external sources can be allocated. The following are examples of the types of losses that can occur that may be beyond the control of the plant. While the losses outlined are being referred to as "outside the control of the plant," that is not to say that correcting these events are not pursued, it just helps to define the type of people who may need to be assigned to resolve the problem.

Raw Material Shortage
If a plant has to reduce production rates or even shutdown because of a shortage of raw materials, then the opportunity gap would be allocated to the "raw material shortage" category in the asset utilization model.

Sales Demand

Some plants produce products whose demand is seasonal. During periods of peak demand, the business plan requires the plant run at maximum capacity in order to maximize profitability. However, during periods of off-peak demand, the business plan often requires the plant to run at reduced capacity. In this case, all production not made could be allocated to a "sales demand" category.

Acts of Nature
El Niño, hurricane Alicia, tornadoes and the like all have the potential to cause production losses. Plants along the gulf coast all maintain hurricane preparation plans that include shutting down the plants when certain threshold criteria are met. And while plants in California cannot necessarily prepare to shutdown plants in the event of an earthquake, they can and do experience production outages when earthquakes occur. For this reason, and depending on the geographic location of a plant, it is necessary to include a loss category called "acts of nature."

Utility Shortage/Outage
Plants that are dependent on outside suppliers for utilities such as power, potable water, and process gases such as hydrogen, oxygen, and nitrogen may experience losses when their external supply fails.

Permit Limitations
The Environmental Protection Agency, Department of Transportation, Federal Energy Regulatory Commission and many other agencies impose restrictions on plants and businesses based on the products they manufacture. Over a period of months or years, as a plant expands and/or incrementally improves its output, the initial permits issued to plant may become the limiting factor in how much product they are allowed to produce. Under these circumstances, the lost production should be allocated to a "permit limitation" category.

While some losses, such as those defined above, are the result of events outside the direct control of the plant, it is more common to find that the causes of loss are within the control of the plant. Examples of these causes follow.

Planned Shutdown or Turnaround
If you want to raise the level of awareness about how much it costs your plant (in terms of lost production and not just added maintenance cost) to schedule that yearly turnaround, then be sure to include this category in your asset utilization model.

Process Control
The systems (be they pneumatic or digital) used to control processes in today's plants continue to grow more complex every year, and at an increasing rate. With the complexity comes the increased probability that a process control fault will cause production losses, which drives the need for a "process control" loss category.

Standard Operating Procedures
Not only are the systems used to control plants more complex but so are the plants themselves. Standard operating procedures are an integral part of the operation and maintenance of every plant. The procedures define the steps to be followed to handle all of the normal and abnormal operating conditions. However, in cases where the procedures are misused, misapplied or ignored, losses can and do occur.

Product Quality
Opportunity gaps may also be attributable to product quality.

Equipment Failure
Equipment failure is probably the most commonly used, and often abused, category of loss in an asset utilization program. By abused, I am referring to the fact that many production losses are blamed on "equipment failure" and left at that. No attempt is made to determine the root cause of the equipment failure. Another important point about the equipment failure loss category is that in reality, every lost production incident that occurs at a plant involves a piece of equipment.

Note: When possible, avoid the use of catchall categories such as "other" or "miscellaneous." Identifying solutions to solve "miscellaneous" problems usually proves to be quite difficult. If you do end up including one of those categories in your model use them sparingly, and question them vigorously.

Due to the varied nature of the plants and businesses that fall under the umbrella of the hydrocarbon processing or chemical processing industry, it is not possible to define every potential reason that an asset utilization loss may occur. However, those outlined above provide a good overview of what must be considered when developing an asset utilization model.

With as little as a few weeks' data, it is possible to determine the magnitude of the opportunity that exists for a plant or business and to determine the value of continuing an asset utilization program. It also becomes possible to look for the common cause(s) of poor performance. In the next section we will take a look at ways we can utilize the data collected in an asset utilization model to help focus reliability improvement efforts.

Making the Data Talk to Us

The following examples illustrate how companies can and have utilized asset utilization to improve plant and business performance. The list is by no means all-inclusive, but chances are that at least one of the examples represents a situation that a plant or business will face.

Lost Profit Opportunity

Imagine that you are a business manager responsible for three plants that have been collecting asset utilization data and calculating their lost profit opportunity (LPO = total product lost * profit per unit or output) for the past year. At year-end you receive a report which includes the lost profit opportunity chart shown in Figure 1. Assuming that the business conditions are expected be the same next year, what does the data tell you? Well, the magnitude of the lost profit opportunity provides two things, 1) it defines quantitatively where to focus capital and resources, and 2) it also defines how much money you could consider spending to correct the problem(s).

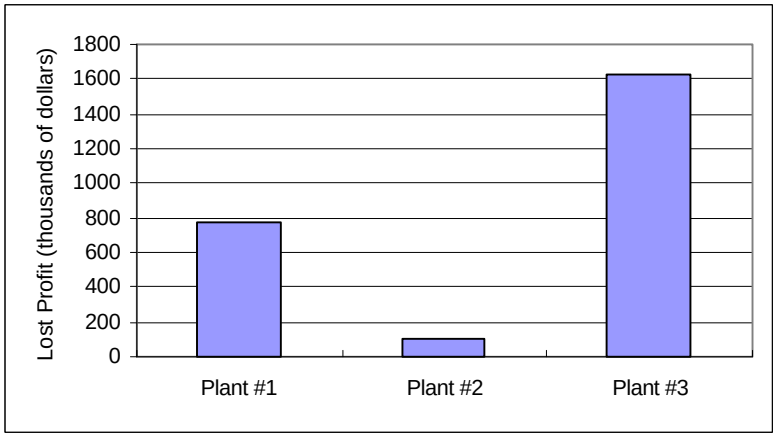

Figure 1 - Lost Profit Opportunity

To Expand or not to expand?

In many plants, the first thing that comes to mind when the plant is not able to meet its' production requirements is, "we need to expand." However, failure to understand just how much "hidden plant" exists in a plant can lead to the unnecessary expenditure of capital. When a company is faced with the decision of how to allocate its capital budget for the next fiscal year, it would be valuable to understand where each of its plants stand with respect to the utilization of their existing assets. For example, if each of the two plants

shown in Figure 2 were requesting capital for projects aimed at plant expansion, management's first question for Plant B should be, "What have you done, or are you doing to better utilize the existing assets?" Plant B's requests for capital would be better stated as a requirement for eliminating the cause of their opportunity gaps. The decision then on how to allocate the capital would be made based on the profit gained by expanding Plant A, or improving Plant B's asset utilization.

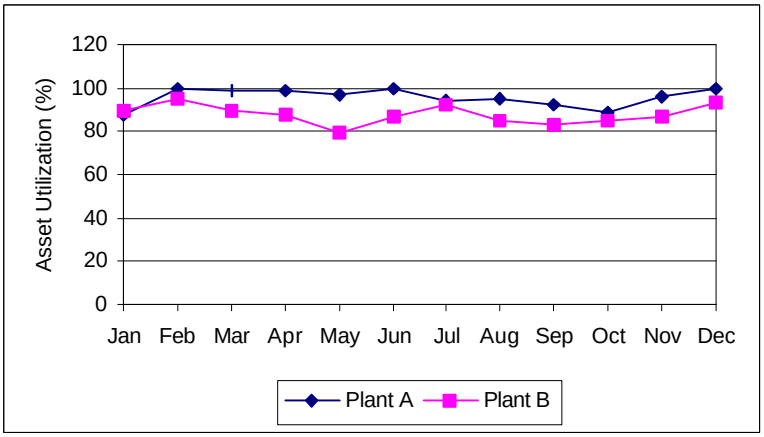

Figure 2 - Asset Utilization Comparison

How good are my equipment standards?

An asset utilization model that includes a discipline category can provide insight into the quality of equipment standards. Say for example that all lost production due to equipment failure is allocated to an "equipment" category which is then subdivided into disciplines like, instruments, electrical, piping, vessels, rotating, etc. After collecting even just a few months worth of data, it would be possible to create a chart such as that shown in Figure 3.

The potential value of this information is two-fold. First, as plant owners and operators the data can be used to quantitatively relate to the engineering group just how significant, in terms of dollars, the deficiencies in the engineering process or procedures are. From the engineering perspective, they now have cold hard facts that they can use to sell management on the need to work on improving their standards.

Keep in mind that for both the production and engineering groups, two problems always exist: 1) not enough resources to work on the things that need to get done, and 2) not enough capital to do the work. An adequately designed asset utilization model may provide the cold hard facts of how much it is costing the company not to take action.

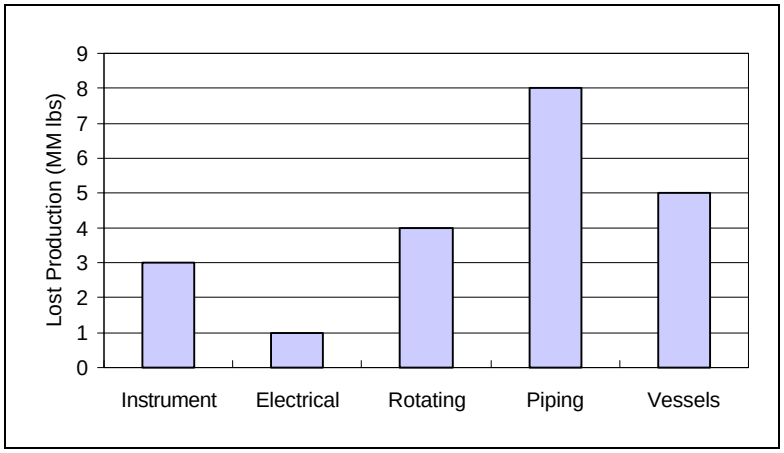

Figure 3 - Asset Utilization Losses by Discipline

How good is my design process?
An asset utilization model that includes a "process" or "systems" level of measurement can provide insight into the quality of a design process. Say for example that Figure 4 represents the total lost production by system for eight plants in a business. By simply having a systems level to which losses are allocated, it is possible to discover where the biggest opportunities lie. Through the application of root cause analysis it may be determined that design of the boiler feedwater systems in each of the plants was less than adequate. If the same engineering, procurement and construction (EPC) firm designed each of the plants, it might even be possible to demonstrate quantitatively that the technology they are using is inadequate. The opposite of this concept is also true. If you were in the process of designing a new plant, wouldn't you want to duplicate the design of the hydrogen system or the other systems in the plant that never show up on a lost production chart?

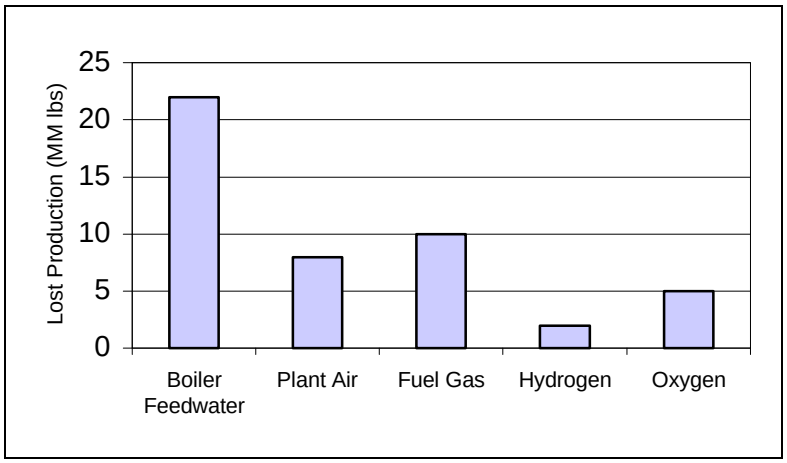

Figure 4 - Asset Utilization Losses by System

The examples provided so far were focused on analyzing and understanding at what levels of the plant or business losses are occurred. The charts indicate where to focus reliability improvement efforts, i.e., which plant, what discipline, which system, but not necessarily, what to go work on. Determining what to focus on is an outcome of charting the causes of loss.

What are my biggest causes of loss?
Knowing what causes asset utilization losses in a plant or business should set the focus for reliability efforts. Maintenance and reliability professionals should be focused on eliminating opportunity gaps *regardless of cause*. Too many times maintenance and reliability professionals are focused on improving the mean-time-between-failure (MTBF) for equipment (particularly rotating equipment) in their plants, when in reality equipment may not represent the most important opportunity to improve profitability for the business.

For example, Figure 5 represents asset utilization losses by cause (both internal and external control) for a plant for a six-month period. The reliability engineers supporting this plant were focused on improving the MTBF of the rotating equipment, one type of equipment that makes up the "equipment failure" category, even though further analysis of the data revealed that none of the equipment failure losses were caused by rotating equipment. As it turned out, several piping failures were to blame for the "equipment failure" production losses, but there were no efforts underway to investigate the cause(s) of the piping failures. Nor was there any focus in the plant on how to reduce or eliminate the losses incurred by the 30-day planned shutdown.

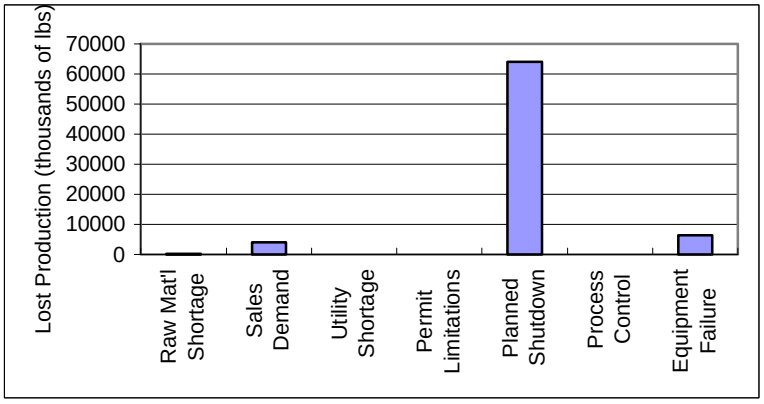

Figure 5 - Asset Utilization Losses by Cause

In summary, what the data tells us is a function of the loss categories contained in the asset utilization model. The magnitude of the problem(s), as shown by the various categories, can and should change over time as a result of a shift in focus as problems are identified and solved.

Conclusion

Most reliability improvement efforts fail to demonstrate financial results because they are focused on activities, the nose count of problems, and not on the business cost of unreliability (4). While no single measure can provide a clear performance target or focus attention on all critical areas of plant performance, asset utilization is a metric that should be used to focus reliability improvement efforts because it focuses on eliminating the cause(s) of business opportunity gaps. And the magnitude, in terms of dollars, of the business opportunity gaps generally far exceeds the cost of maintenance.

Make no mistake; focusing reliability efforts on the systematic elimination of the cause(s) of asset utilization losses is one of the most cost-effective methods for increasing plant profitability.

References

(1) Amoco Corporation, **Annual Report**, available on the Internet at http://www.amoco.com.

(2) Exxon Chemicals, **Annual Report**, 1997, available on the Internet at http://www.exxon.com.

(3) The Dow Chemical Company, **Annual Report**, 1997, available on the Internet at http://www.dow.com.

(4) Barringer, H. Paul, **Reliability Engineering Principles Training Seminar**, August 1993.