PREMO XPERTS® Risk Based Analysis Module

Introduction

One method for optimizing limited resources and reducing the possibility of equipment failures that has been in use in various industries for some time now is risk-based analysis (RBA). RBA is a procedure for ranking or prioritizing equipment for maintenance purposes, based upon risk. Risk is the combination of probability and consequence. Probability is the likelihood of an event occurring, in this case an equipment failure. Consequence is a measure of the damage that would occur if an equipment item failed.

RBA can be based on either qualitative or quantitative methodologies. Qualitative methods provide a ranking of equipment, based largely on experience and engineering judgment. To accurately judge the risk of equipment failure, the effects of the failure include the full range of consequences, including repair cost, safety impact, environmental impact, public image, regulatory impact, and lost production. Many of these items cannot be assigned a cost in dollars, yet are very significant plant considerations. Quantitative risk-based methods use several engineering disciplines to set priorities and develop programs for equipment inspection. Some of the engineering disciplines include nondestructive examination, system and component design and analysis, fracture mechanics, and probabilistic risk analysis. Quantitative analysis methods are expensive and time consuming, and often there is insufficient information available to conduct an accurate quantitative analysis. For these reasons, quantitative analysis is considered outside the scope of an Asset Reliability Improvement Program.

As a result, PREMO XPERTS® includes a method for qualitatively analyzing the importance of equipment failures so that further analysis can concentrate on the equipment with the most significant impact. This qualitative method rates the risk associated with each piece of equipment based upon an evaluation of the equipments' failure effects and likelihood. The PM Task Selection and Non-Critical Evaluation section of the Asset Reliability Improvement process will focus the majority of the effort on the highest risk equipment, and will review other equipment only to the extent necessary to ensure that appropriate basic equipment needs (e.g., lubrication, filter changes) are met, or to determine if "run to failure" is the best approach.

Overview

Equipment Risk Ranking includes several steps to determine the risk associated with equipment failure. These steps first identify failure effects by considering the system and plant required functions, and then determining which equipment failures can result in the identified failure effects. The steps required for Equipment Risk Ranking are as follows:

❑ Identify Failure Effects and Weight Values

❑ Failure Modes Analysis

Identify Failure Effects and Weight Values

A risk model must reflect a corporation's strategic plan and objectives. It establishes the logic for qualifying the impact failure has on these objectives and builds an effects list with weight values to measure the impact consequences.

This step involves the identification of the failure effects and the assignment of weight values to each effect. The effects should address all areas of concern relative to the process and plant. It is important that each effect be directly related to a direct cost (e.g., lost sales) or other significant impact item (e.g., environmental, safety, regulatory) as defined in the Risk Model. Examples of effects and weight values are shown in **Table 1**.

Failure Effect Reference

ID	Description	Weight
A1	1 - Environ.-Written Notification/Personnel Hazard	10
A2	1 - Environ.-Non-Written Notification/Personnel Hazard Low	7
A3	1 - Environ./Other Reg. Event - Non-Reportable	3
A4	2 - High Repair (greater than $100,000)	8
A5	3 - Moderate Repair (between $10,000 and $100,000)	5
A6	4 - Low Repair (less than $10,000)	3
A7	5 - No Effect	0

Record: 1 of 11

Table 1: PREMO XPERTS® sample Failure Effects and Weight Values

Failure Mode Analysis (FMA)

Equipment Risk Ranking involves performing a failure mode analysis (FMA) for equipment. Each plausible failure mode (e.g., pump stops, external leak, poor performance) for each piece of equipment is listed, and its failure effects identified from the list of effects established earlier. Note that this is a "high level" FMA which requires only an understanding of basic equipment functions, and not detailed knowledge of equipment piece-parts nor overhaul procedures.

Once the failure effects are determined for each plausible failure mode, then a rank value is calculated which takes into consideration both the effects and likelihood of the failure mode. Whether or not a failure mode will be evident to operations personnel can also be included as a factor in the rank value calculation.

The results of these FMA/ranking analyses can be used to generate an ordered listing (i.e., Pareto chart) of equipment by rank value *(***Figure 2***).* Ranking results can be used to help prioritize the allocation of resources for other parts of the detailed analysis and to guide the evaluation of PM task effectiveness. The results of this risk ranking can also be used for other plant activities (e.g., to help prioritize or allocate resources for performing activities).
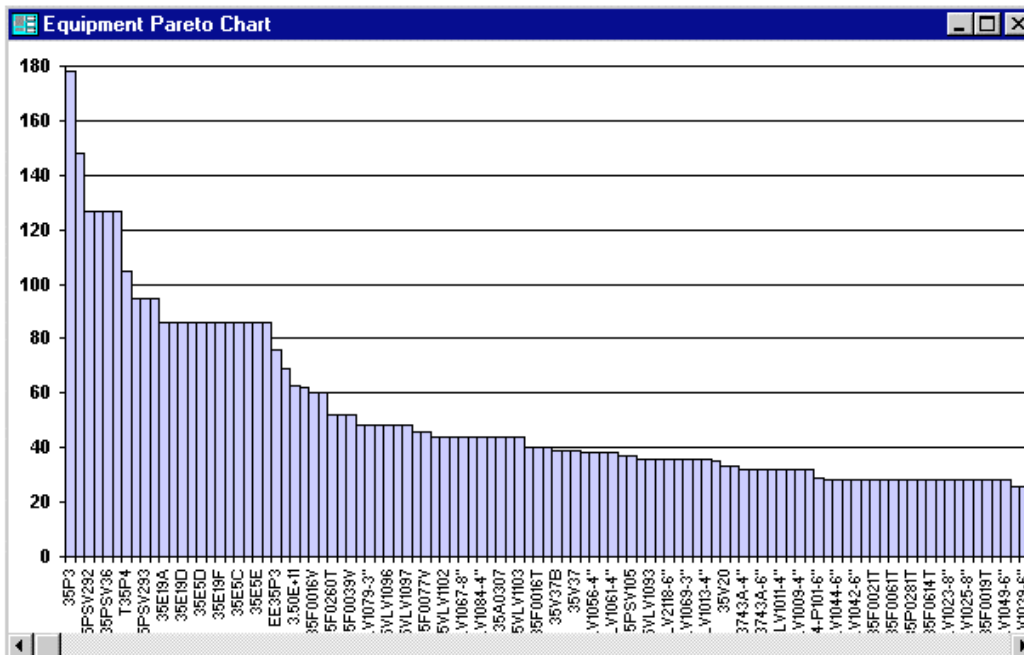

Figure 2: PREMO XPERTS® sample Pareto Chart

RBA in PREMO XPERTS®

RBA is accomplished in PREMO XPERTS® Failure Mode Analysis module. Figure 3 shows the main form.

Figure 3: PREMO XPERTS® Failure Mode Analysis form

FMA Module Procedure

Equipment Assignment

Users can group 'like' equipment to help shorten the evaluation cycle. Like equipment share similar physical and operating characteristics such as environment, equipment type, function, and duty cycle.

Functional Description

Equipment function(s) are described qualitatively in several statements. Depending upon the type of Equipment, functions may be "process related" (e.g., provide flow, increase pressure, control flow), "safety or environmentally related" (e.g., containment of product/fluid), "protective" (e.g., shut down other Equipment on low oil pressure), or any combination.

Failure Mode Assignment

To start the process of identifying the failure mode, likelihood, and effects, double click in the white area of the **Failure Mode and Effect** field. The Failure Mode and Effects Assignment window appears and a pull down of failure modes available is on the top left (see Figure 4 - noting the Failure Mode combo-box).

The user reviews the list of available failure modes, which is generated automatically by PREMO XPERTS® based upon the equipment type of the assigned equipment. Not all failure modes need to be

chosen; however, if one is not present which is deemed necessary it can be added automatically by selecting the 'All' checkbox and choosing from the expanded listing.
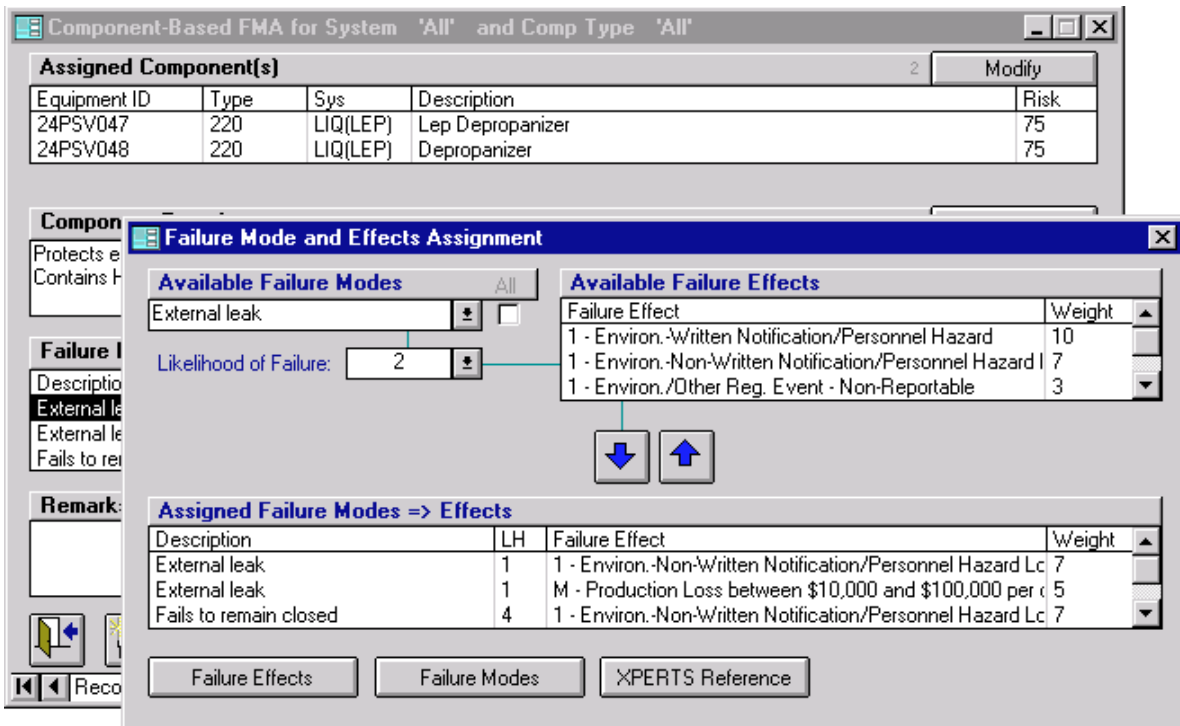

Figure 4: PREMO XPERTS® Failure Mode and Effects Assignment

Choose a Failure Mode Likelihood

After selecting a failure mode, select the corresponding Likelihood in the field below the Failure Mode field (see Figure 3 noting the Likelihood combo-box). The Likelihood for each Failure Mode should be based upon facility-specific failure history, if available, and assigned a value of 1, 2, 4, or 8, based upon the definitions included in Table 2:

Likelihood	Definition
1	This Failure Mode is very unlikely. There is no evidence (e.g., work order) of this Failure Mode occurring, and the analysts are not aware of this failure happening neither on this equipment nor on similar equipment used in similar conditions within the plant or industry.
2	This Failure Mode is unlikely. There is evidence (e.g., work order) of this Failure Mode occurring, or the analysts are aware of this failure happening approximately 1 or 2 times in 5-to-10 years; or the conditions resulting in previous failures of this equipment have definitely been resolved; or analysts are aware of this failure happening more than once on a similar piece of equipment that is operating under similar conditions
4	This Failure Mode is likely. There is evidence (e.g., work order) of this Failure Mode occurring, or the analysts are aware of this failure occurring, approximately 2-to-3 times in the last 5 years.
8	This Failure Mode is very likely. There is evidence (e.g., work order) of this Failure Mode occurring, or the analysts are aware of this failure occurring, on the specific Equipment many times.

Identify Failure Effects

A list of failure effects, their descriptions and associated weight values can be found in PREMO XPERTS®, User Guide. The effects are developed to consider all areas of concern to plant personnel and management, including, but not limited to, product quality, personnel safety, environmental safety, regulations, and economics.

For each Failure Mode, the applicable failure effect(s) are identified. Determine which effect(s) (found in the listbox on the Assignment Window) could occur as a result of the Failure mode. Use the following guidelines for determining the effects:

❑ Consider the full range of process and component operating conditions (e.g., startup, operating, shutdown) when considering whether a particular failure effect could occur.

❑ Consider the worst realistic case. Do not rely on human intervention to eliminate a failure effect unless someone is regularly monitoring the process or equipment, would easily detect the failure, and would be able to take mitigating action to avoid the effect.

The choices for effects are in the listbox on the right of Failure Mode and Effects Assignment window. Each appropriate effect is selected and the down arrow is used to document the failure mode/likelihood/effect link. Because each of the effects has a weight value, a risk value is calculated by multiplying the likelihood value by the sum of the weight values of each effect (Figure 3 noting the Effect Field).

This process is completed for each Failure Mode. Closing the assignment form calculates the total equipment risk value and is shown in the Assigned Equipment field (Figure 3).

Completing the Failure Mode Analysis

Perform the preceding process on all equipment in the system in analysis. At this point, Risk Based Analysis is complete and each FMA record can be marked as critical or not critical. The decision of whether the equipment is critical or not should be performed after the results of the equipment risk ranking are reviewed.

Interpret Equipment Risk Ranking

Once all of the FMAs have been completed for a system, review the Equipment Risk Ranking Chart (i.e. Pareto Chart). The Pareto Chart is a report generated by PREMO XPERTS®.

The Equipment Risk Ranking report and PREMO XPERTS®, FMA module (Figure 3) is used in performing the next steps.

The "high" ranked equipment should receive a detailed Analysis and Task Selection. The FMA records should have the Critical field changed to "YES." This will create a PM Task Selection record and will ensure the detailed review.

The "middle" ranked equipment should be reviewed for any equipment which intuitively should be given a detailed review. This equipment generally is critical based upon the effects of failure but it risk was moderate due to the low likelihood of failure. Choosing a "middle" ranked equipment for detailed review should be the exception, not the rule. For these exceptions, change the Critical field in their FMA to "YES."

The remainder of the "middle" ranked equipment will receive a quicker review. The FMA records for this equipment should have the Critical field changed to "NO." This will create a Non-Critical Evaluation record.

The "low" ranked equipment will also receive a quick review during Non-Critical Evaluation. The FMAs for this equipment should also have the Critical field changed to "NO."