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**A MANAGEMENT GUIDE TO BALANCING
CONTROLLING MAINTENANCE INVENTORY
COMBINING TPM AND RCM**

RCFA Saves Inland Steel \$1.15 Million

By John Van Auken, Inland Steel Co.

Inland Steel is committed to improving the reliability of its plant operations to reduce costs and downtime and increase productivity. Recognizing that substantial savings could be achieved by reducing or eliminating chronic system and equipment failures, the company provided extensive training in root cause failure analysis (RCFA) to 50 reliability engineers and more than 150 field employees.

The RCFA training, conducted by Reliability Center, Inc., emphasized the importance of approaching failure problems in a systematic, logical process and provided a proven methodology to identify, analyze, and verify the root causes of recurring failures.

The classroom training provided a valuable base of knowledge and skills, but applying these skills in actual workplace situations is the real test. The company recently had an opportunity to do that and the results were gratifying, not only in measurable savings but also in the satisfaction that

comes from tackling a problem and solving it.

The problem

There had been nine catastrophic failures of the lance carriage assemblies in the site's basic oxygen furnaces at an approximate cost of \$250,000 each. The mean time between failure (MTBF) of these occurrences was 2.5 months.

The lance carriage assembly is an elevator weighing approximately 11 tons that raises and lowers an oxygen lance, a mechanism that blows pure oxygen about 80 ft at a speed of Mach 2 in and out of the steel-making vessel.

The lance provides the agitation to mix the "recipe" according to customer specifications. The recurring failure of the assembly presented an opportunity to use RCFA in the field.

The classroom training included a five-step method for addressing failures: preserve failure data, order the analysis, analyze the data, communicate findings and recommendations, and track to ensure results.

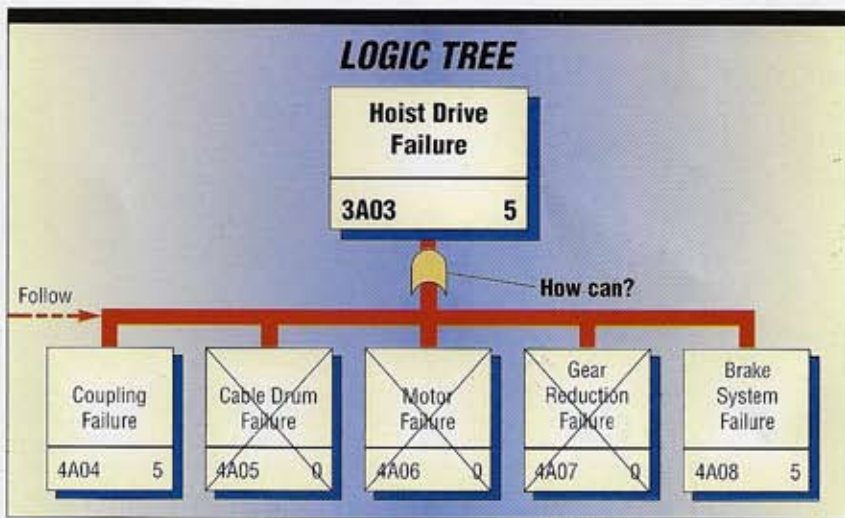
This method compelled the failure analysis team to arrive at logical, verifiable, fact-based conclusions rather than solutions based on guesswork, hunches, or conventional wisdom.

Therefore, the team had confidence in its analysis work and a high degree of certainty that its findings and recommendations would solve the problem.

Applying the methodology

The first action was to collect, preserve, label, log, and analyze all data and parts related to the failure.

The next step was to assemble a multidisciplinary team to analyze the



This logic tree describes the failure event and shows all possible modes of failure. The most significant failure modes are prioritized.

failure. Operations, maintenance, and technical representatives were included. The principal analyst had an electrical background even though the failure appeared to have mechanical roots. His background allowed him to be unbiased and to facilitate the analysis process rather than guide the team to a preconceived conclusion.

The team was faced with taking the pieces of the puzzle formulated from the failure information and putting them together. A logic tree was used, which promoted a disciplined, logical deduction process that forced the team to work backward from failure to physical and latent root causes.

Hypotheses were developed to determine how an event occurred. When all possibilities had been identified, strategies were developed to verify whether the event did or did not happen. Without the failure information, it would not have been possible to verify the hypotheses.

The team kept working until the tree was down to its roots. Two appropriate questions were asked repeatedly until

all the roots were uncovered. The first question, "How can that happen?" was followed by "Why did it happen?" Using this method, the team uncovered the physical root causes of the failure along with the human and organizational root causes.

Certain management or organizational systems (for example, improper lug nut specifications, improper torquing and alignment procedures, and lack of parts inventory) were influencing field employees in making decisions that led to failure.

When the RCFA process was completed, the solutions to the failure were apparent. The next step was to present the team's findings and recommendations in a way that would encourage corrective actions.

The team developed recommendations that they felt management would accept. The recommendations were reviewed a second time because they represented what the team felt would be a permanent solution. The team tried to reject subjectivity and stick to objective solutions based on root causes.

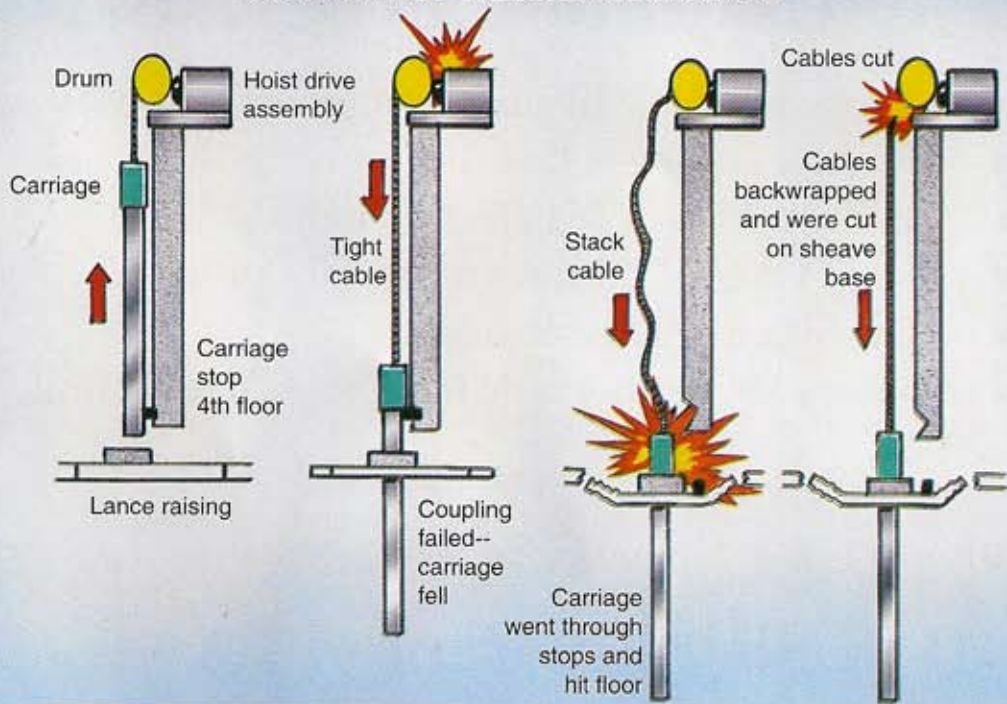
The final presentation to management was designed to convey the information effectively. It was an electronic presentation with pertinent photographs digitized so they could be viewed on a screen. Appropriate parts were passed around so management could see first-hand what the slides depicted.

Management appreciated the level of detail and logical approach. The recommendations were accepted, long-term plans developed, responsibilities assigned, and timetables set.

The immediate actions were to realign the equipment to precision specifications and implement mechanical techniques that would address the physical roots. Because of perceived higher priorities, organizational recommendations including providing alignment training, developing a torquing procedure, and clearing up problems between central and assigned maintenance and inspection responsibilities were not addressed.

However, after changes regarding the physical roots were made, there was not another lance drop for 10

SUMMARY OF FAILURE MECHANISM



Graphic representation of the failure event shows the oxygen lance carriage falling, hitting the floor, and the cable being cut. A five-step method was used to address the failure.

months, resulting in savings of approximately \$1.15 million compared to past performance.

When a "mini" RCFA was performed on the latest lance drop, it was found that 10 of the 11 contributors to the failure had exactly the same roots identified in the initial RCFA. Because action on these recommendations was delayed, another failure occurred. This event reinforced the fact that prompt follow-through on all the recommendations of the RCFA was vital. Currently, the MTBF has improved from 2.5 months to 10 months and it continues to increase month by month.

Management support is key

The results achieved would have been impossible without strong support from management. That support must be active and it must include providing the principal analysts and their teams with the time to meet and analyze failure information. Management must provide the technical, field, or admin-

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istrative resources required to verify hypotheses.

When the systems or lack of systems by which the organization runs are identified, the benefits of analyses can be leveraged to other units. For example, when the lack of knowledge on how to properly align the equipment was confirmed, it was found that the problem was common to other

areas. The same proved to be true for effective torquing.

Many recommendations from the RCFA on the lance carriage assembly failure were implemented site wide. Perhaps the greatest benefit of the entire process has been that other areas learned from this failure and were able to prevent failures of their own.

Now when there is a failure, no one jumps right in and tries to fix it. A mini RCFA is performed, including the collection of appropriate failure information. This information is used to develop and implement countermeasures. The results are fewer delays, longer MTBF, and more reliable production.

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